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TULIPS

By

DAVID GRIFFITHS

Senior Horticulturist
Division of Fruit and Vegetable Crops and Diseases
Bureau of Plant Industry

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UNITED STATES DEPARTMENT OF AGRICULTURE
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TULIPS[1]

By David Griffiths,[2] *senior horticulturist, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry*

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INTRODUCTION

The tulip is a close relative of the lily. Western Europe first got acquainted with it about the middle of the sixteenth century, when it was introduced from Turkey. It gained rapidly and constantly in favor and is today the most popular and most extensively used, in the United States at least, of any of the spring-flowering bulbous plants.

Its rise in popularity has been exceedingly rapid in the last 15 years. There are indications that domestic production will increase rapidly, for it has been demonstrated time and again that bulbs equal in quality to any ever imported can be grown here over a wide range of conditions. The demonstrations have been both experimental and commercial, leaving no doubt as to quality for either the garden or the forcing bench.

The tulip is so well known that a detailed description of it would be superfluous. Old and young alike are so familiar with it as to call it by its right name, and they even recognize most of its great divisions.

It must not be understood that anyone can produce tulips, for such production is a specialized job. It is not an old lady's task either.

[1] This circular supersedes Department Bulletin 1082, The Production of Tulip Bulbs. It is designed to guide the commercial grower, but an application is also made of the commercial practices to the needs of the householder who uses tulips for ornamentation.

[2] Dr. Griffiths died Mar. 19, 1935.

nor one to be performed in a back yard; but it requires capital and labor, push and energy, thought and planning, agitation and advertising, like any other business. While the task is not so difficult but that any bright young American can compass it readily, it is one that must have application and constant attention. The price of the bulbs is relatively low; consequently the production must be on a commensurate scale to insure a profitable income. The equipment, while not expensive, must be provided, for tulips are difficult of production or preparation for the market on a makeshift basis. There should be housing facilities under complete control for holding the bulbs during the dormant season and for packing and preparing them for the market. Provision must also be made for sizing. Aside from these things the ordinary tillage implements and tools will suffice.

The majority of tulip growers in the future may produce some other commodity besides tulips, for the reason that this crop is quite exacting in its rotation requirements. With American methods of culture it may not be safe in the humid bulb regions to attempt to produce more than one crop of tulips in 3 years on the same land. Economic considerations may force the use of some other crop in conjunction with tulips. Two bulb growers years ago established dairies in connection with their bulb nurseries for the dual purpose of rotation and fertilizer supply.

It may be said, therefore, that at the present time the problems confronting the prospective tulip producer relate to the business aspect of the subject and to compassing the few requirements of the crop rather than any concern about the adaptability of the tulip to our recognized bulb-growing regions.

LITERATURE

There are few garden subjects that have been treated so well or so often as the tulip, and its literature is quite up to date.

The real student of the tulip cannot afford to be without access to the treatise by Jacob (*5*).[3] This is especially valuable for the carefully selected and chronologically arranged "incidents" in the history of the tulip between 1554 and 1910. It contains the most carefully considered bibliography published. Hall (*4*) has presented the morphology, taxonomy, description of natural species, breaking, and other features. Wister (*14*) has devoted a large space to tulips and has presented the history and a list of varieties offered by the leading bulb growers in 1929.

The two publications by the Royal Horticultural Society of London (*9*, *10*) are indispensable to the student and very useful for reference to anyone who grows tulips. The investigator dealing with the tulip under greenhouse and conservatory conditions would profit from having access to several papers by Blaauw and his coworkers (*2*). Of importance on account of the intimate touch is the little book by Weston (*13*).

Many of the large bulb dealers issue, besides informative catalogs, pamphlets on how to grow the bulbs.[4] These, of course, handle the

[3] Italic numbers in parentheses refer to Literature Cited, p. 63.

[4] These pamphlets are too numerous to list. The reader is referred to any of the large dealers for them.

subject from the consumer's viewpoint and are very useful. Of this general nature was a 30-page illustrated pamphlet by Dix (*3*) from the Netherlands, but sold by some of the leading bulb houses in this country some years ago. Allen (*1*) gives a useful discussion of the tulip in a few pages.

A large, varied, and most important part of the literature of the tulip is to be found in trade and garden papers. These present useful information on the tulip, generally written by an expert on some phase of the subject, and it is, of course, up to date.

TULIP CULTURE IN THE UNITED STATES

Not so long ago it was emphatically questioned whether any part of the United States was adapted to the culture of this or that group of bulbous stocks. We have now progressed so that the only question that is agitated is, "Can we grow at a profit?" It is conceded that the stocks can be produced, but can they be grown economically enough to compete with the foreign article? A perusal of the following pages it is believed will answer the question in the affirmative.

Of course, it is possible to grow tulips or any other bulb stocks poorly in a region perfectly adapted to their culture. Such poorly grown bulbs have doubtless found their way into the market of many buyers, but this is not proof that the country cannot grow good stocks. It proves nothing except that the bulbs in question were not fit. There has been altogether too much argument, based on the experience of some individual, over bulbs improperly grown or handled. Conclusions have been formulated based on notions gained in the handling of stocks furnished by growers who may have been not only without experience in the growing but often without knowledge of the constitution of good stocks.

There is little to be gained from a comparison of domestic and imported bulbs unless the comparisons are in the first place fair and extend far enough back so that it is known the domestic bulbs represent at least an average of the possibilities of the production of a particular region. From the nature of the case, satisfactory results with domestic stocks can be accepted as proof of the possibilities within our borders, but negative results may prove simply that the particular bulbs were unfit for some cause. Failure may perchance be due to the unsuitability of the region, or as often it may be entirely due to improper cultural methods or conditions in storage.

The proof that good tulip bulbs can be grown in this country is not far to seek. Government experience now extends over a period of 20 years; that is, stocks of tulips imported into this country 20 years ago are still grown intact on Puget Sound. They produce and reproduce in a very satisfactory manner, and they perform in beds and on benches as well as imported bulbs.

Little was it realized by the public that during the last 3 years of the old Congressional seed distribution (discontinued in 1923) the 110,000 tulip bulbs which it contained were all domestic grown. Had these stocks been unfit, someone would certainly have found it out. Little has it been realized about Washington, D. C., that the score of tulip beds on the United States Department of Agriculture grounds for the past several years have been predominantly of domestic-grown bulbs from stocks that had been in the country

a dozen to a score of years. If there is an inherent poor quality in the domestic-grown tulip bulbs it certainly would have shown up in this conspicuous situation, but it has not been detected. No one has noted any slump in the quality of vernal display as the domestic stocks have been substituted for the traditionally imported materials.

A score or more of growers are having marked success in production and know what they can do. Greenhouse men in the Northwest especially are also familiar with the good quality of domestic tulip stocks and prefer them to others because they perform better.

In this circular it is hoped to show how to produce high-quality tulip stocks, and why the domestic bulbs should be and are the equal of any.

WHERE TULIP BULBS CAN BE GROWN

In a general way it may be said that tulips are about as adaptable to conditions of soil and climate as oats; indeed, the writer knows of no other crop that is a better indicator of tulip requirements than this old grain crop, which is most successful in the North, less so in regions having cold winters and hot springs and summers, and difficult, to say the least, in regions where the warm summers are coupled with very mild and short winters. If it be argued that oats are not very adaptable, it can be replied that they are adaptable enough so that an abundance can be produced for the country's needs. The same is true of tulips.

The ideal climate for the production of tulip bulbs has a cool autumn, a snappy winter, and a long cool spell of weather for 2 to 3 months in the spring or until the middle of June. At all times there must be a sufficient supply of moisture for plant growth. Tulips are successfully grown where a rainfall of 60 inches obtains. This does not bespeak any definite amount of rainfall, for variations of 30 to 60 inches a year are known to produce good bulbs, the requirement being simply a suitable supply of moisture in the soil so that the plants do not suffer from drought on the one hand nor from stagnant water about them on the other.

The regions in which the writer has had experience in tulip culture are representative of great extremes. A realization of the degree of success or failure attained in these locations will give a very good picture of the requirements of the crop and the character of the regions to which tulip culture is adapted.

At the United States Bellingham Bulb Station,[5] Bellingham, Wash., it is considered that the culture of tulip bulbs has been unqualifiedly successful. At the Arlington Experiment Farm,[6] Rosslyn, Va., near Washington, D. C., it is considered that the culture of tulip bulbs is eminently justified although from some points of view not so pronouncedly successful as at Bellingham. In the tests at the Coastal Plain Branch Station at Willard, N. C., the bulbs have not maintained the size nor the reproductive qualities that are to be desired, indicating a possibility of a cut-flower business and early flowering; but some stocks at least may need to be renewed periodically. At the United States Acclimatization Field Station, Charles-

[5] Hereinafter referred to as Bellingham Station.
[6] Hereinafter referred to as Arlington Farm.

ton, S. C., even the robust Darwins have not made a satisfactory blossoming the first year after importation.

This may be taken as a generalization of the subject. It does not indicate that tulips cannot be grown in some warmer regions, but it does point strongly to the lack of probability of commercial success of bulb production with the common garden varieties. On the other hand, there are natural species of tulips by no means to be despised which seem adapted to a warm climate.

Tulips do not succeed along the Gulf coast. Many have been the failures resulting from attempts to grow tulips in our Southland. The result is always the same. The flowers open at the surface of the soil, if at all, making little or no stem. In short, they do not get cool enough weather to root properly; consequently they do not grow satisfactorily thereafter. However, there are a few species of tulips that seem much better adapted to warm regions than the highly bred forms with which we are familiar. The most conspicuous of these is *Tulipa clusiana*, which has been proved satisfactory as far south as northern Florida. *T. sylvestris*, *T. fragrans*, *T. turkestanica*, *T. praestans*, and *T. persica* also have qualifications. The dainty little crocuslike gem, *T. dasystemon*, is another that has some promise.

Whether these natural tulips can be grown commercially at a profit in the warmer sections of the country remains to be demonstrated, for they reproduce very slowly. In many species one offspring a year is about all that can be relied on from a large bulb, but they can be produced from seed much better than from offsets. If they will thrive for a year or two the South may enjoy tulips in its gardens.

Besides making good growth in a warm region, the coats of most of these bulbs are well adapted to withstand hot and even dry weather in the dormant season. They are thick, hard, and not easily broken—very important attributes in a tulip for such situations.

HARDINESS

The garden tulip is one of the hardiest of our spring-flowering bulbous plants. When planted at a normal depth of 4 or 5 inches to the top of the bulb it seems not to be injured by cold alone. When winter injury occurs it results from heaving and poor drainage rather than from the effect of low temperature. It is not an uncommon thing to find bulbs barely covered with soil going through the winter uninjured, and bulbs lying on the surface will often take root, grow, and flower.

In the autumn of 1926 some bulbs of Darwin tulip City of Haarlem were inadvertently left on the writer's kitchen porch in the District of Columbia, under roof but otherwise fully exposed to the weather all winter. The blossoms inside the bulbs seemed to be in good condition when examined in March. The bulbs grew but did not flower.

The winter of 1929–30 was one of the most severe on record on Puget Sound. Some mixed bulbs of Darwin tulip varieties were left on the bulb-house shelves at the Bellingham Station. The building is a shell, covered with only one thickness of boards. There are no definite observations, but it is safe to assume that the bulbs were

below the freezing point continuously for a period of 3 weeks, and the temperature went to 10° F. An examination in late March showed them to be in apparently good condition. Even the flowers seemed perfect. The bulbs grew when planted but did not flower.

Tulips have been grown commercially in the vicinity of Grand Rapids, Mich., for many years, and even in the Upper Peninsula of the State to some extent. The rigor of the Canadian climate does not deter them, and they may be enjoyed in an ornamental way in the dry, cold, bleak prairies of our northwestern prairie States. Truly this is recommendation enough for their hardiness.

THE TULIP PLANT

The tulip differs from the lily, its next of kin, mainly in the nature of the bulb. Structurally the flowers are very much alike. The floral envelope in the tulip is made up of 3 outer and 3 inner segments (petals) which are very similar and are inserted on the stem just below the triangular seed vessel, which has 6 rows of seed, again similar to the lily. The 6 stamens are inserted at the base of and opposite to the petals.

The tulip bulb produces a plant that generally bears a solitary flower (pl. 1). The stem bears 1 to 3 and rarely 4 or 5 leaves, which are large and clasping at the base, often in robust varieties measuring 8 or 10 inches in length and 4 or 5 inches in breadth, and are arranged on opposite sides of the stem. There is one stem from a bulb, but there are many exceptions. The stems vary from a few inches to about 3 feet in length.

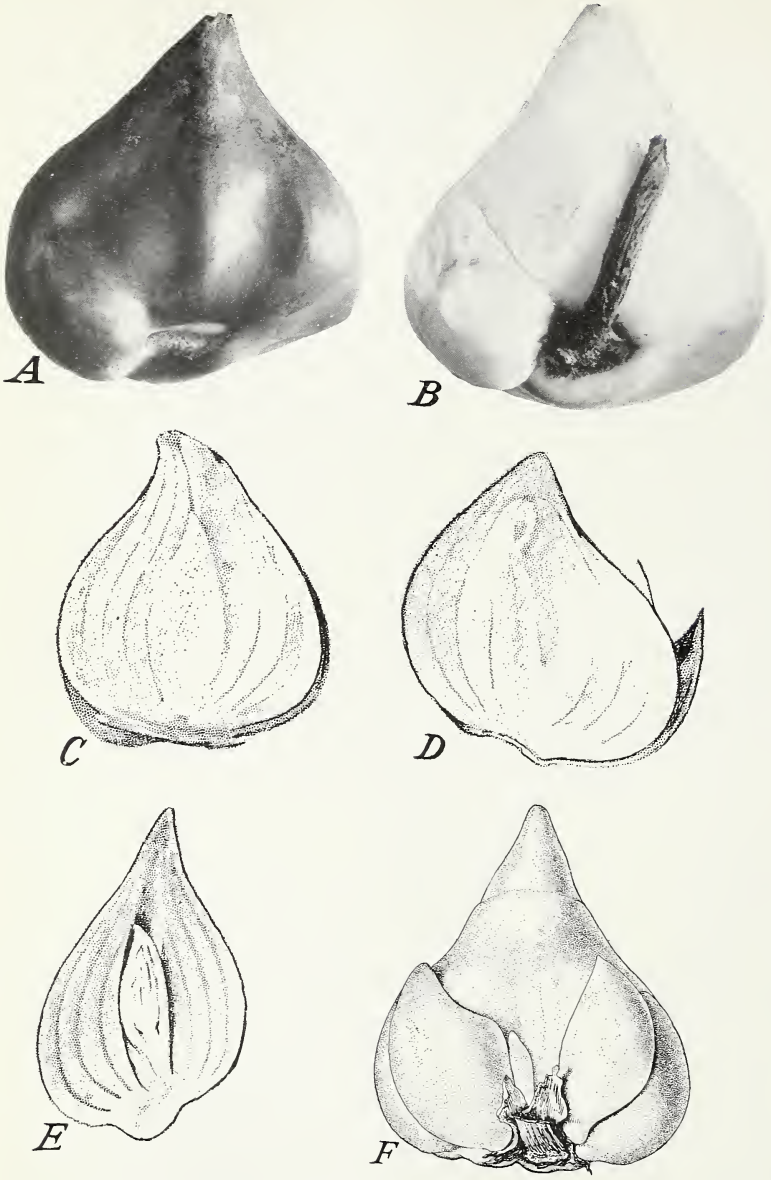
The tulip blossoms in April and early May. The bulbs are ready to dig in late June, but it may take 2 weeks longer for the seed to ripen. In some of the species at least the maturity of the bulb and seed is simultaneous, but in the garden tulip the leaves are often dead some time before the seed is fit to gather.

THE BULB

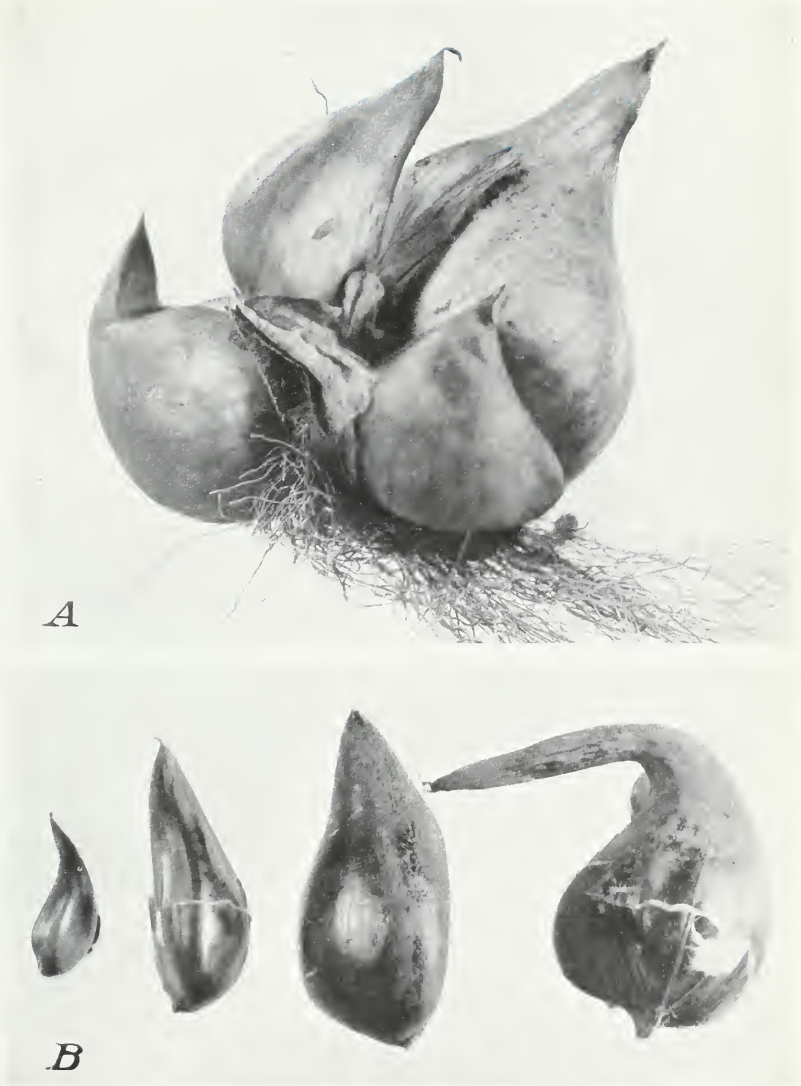
During the dormant season the whole tulip plant is condensed into a fleshy, roughly globular structure called a bulb (pl. 2, *A*). It is designated a bulb because for the greater part it is made up of concentric layers of scales; were it solid, like the crocus, it would be a corm; if elongated, solid, and scaled, like an iris, it would be a rhizome. The structure of the tulip is similar to that of the daffodil and the hyacinth with the important differences that the tulip has a comparatively small basal plate and a continuous brown coat entirely enveloping it. These distinctions, together with its characteristic shape, distinguish it readily from most other bulbs.

The mature tulip bulb as recognized by the gardener is made up of 3 main parts (pl. 2, *C* and *D*). The concentric layers forming the greater part of the bulb are looked upon as greatly modified leaf bases. The basal portion to which the scales are attached is called the basal plate, which is a greatly condensed and much modified stem. The third main part of the bulb is the outer membranous coat, morphologically of the same derivation as the concentric scales, of which the bulk of the bulb is formed. This brown coat or

Tulip plants: *A*, Yellow Prince; *B*, Sieraad van Flora, one of the robust Darwins; *C*, Thomas Moore.



A, Typical tulip bulb, such as is usually purchased for decorative planting; *B*, a bulb similar to *A* with the outer coat (tunic) removed to show the bulblet flattened against its side close to the base of the old flowering stem, which is still attached; *C* and *D*, sections of a tulip bulb a few days after digging, showing structure of the bulb as made up of a basal plate and scales and the whole surrounded by an outer tunic; *E*, a similar section at planting time, after the flower has developed; *F*, a bulb of cottage tulip Mrs. Moon, showing 4 bulblets at the base; this will give 1 normal flower and 3 small ones the next year—a cheap bulb to grow.



A, A Darwin tulip bulb (Professor Rauwenhof) as dug. In this case the clump consists of a large, merchantable bulb and 3 large splits, all of which will blossom and make merchantable bulbs the next year; *B*, 2 categories of bulbs; on the right a long-necked or round bulb; on the left 3 splits, at least 1 of which will blossom and mature the next year.

A, Tulip droppers; portions of bulbs dropped to lower levels; *B*, a long-necked bulb produced from a split of the previous year which has itself given rise to 3 small, nonflowering offsets; *C*, stem of cottage tulip Mrs. Moon showing a 10-cm bulb developed in the axil of the lower leaf, large enough to blossom; *D*, variation in size of flowering bulbs in Cardinal's Hat tulips, ranging from 6 to 13 cm. All are mother bulbs and will flower the next year.

tunic envelops the entire bulb, and until it is ruptured in some way the delicate tissues within are about as effectively protected by it as a grain berry. The inside of this coat is usually more or less hairy. In certain species of the genus *Tulipa*, to which the garden tulip belongs, the inside is proliferated into a thick coating of wool, even in some cases approaching a felty structure.

At planting time the center of the bulb contains a complete young tulip plant, all the main parts of which may be recognized by the unaided eye (pl. 2, *E*).

The general appearance of the tulip bulb is very characteristic; there are few other bulbs that in any way resemble it. Possibly the nearest approach to similarity is with *Bulbocodium* and *Ixiolirion*, but these as a rule are much smaller and present other differences.

The mature tulip bulb is mostly more or less flattened on one side, which may be called the front side, for it is the one next to the stem. At the base of the front side there is a scar where the flower stem of the previous year was attached, and extending upward from it there is more or less of a groove impressed into the bulb by the stem during its growth. The back side of the bulb is convex, its apex bluntly pointed. The base is more or less flattened, but much smaller and thinner in proportion than the comparable structures in the daffodil and the hyacinth.

On one side of the stem scar at the base of the bulb and flattened against its lower edge is a secondary bulb or bulblet (pl. 2, *B*), readily recognized by a slight bulging of the unruptured protective covering. The bulblet is firmly attached and in reality is a part of the tulip bulb that is purchased for planting in autumn. The better and more vigorous the growth the larger and more pronounced this bulblet is, and it is much more prominent in some varieties than in others.

The basal plate has been referred to as a modified stem. One of the functions of a stem is to bear buds. This basal plate shows its stem nature by its production of buds. In the development of the tulip plant the flowering stem and leaves grow out of the tip of the bulb. Simultaneously with the growth of the plant above-ground there develop from the buds on the basal plate 1 to 6 entirely new bulb structures, depending on the variety, suitability of the environment, cultural conditions, etc. The bud next to the stem produces as a rule the largest or the full-sized merchantable one, and the other buds develop smaller sizes. Within the protective coat of the larger bulb and to one side of the stem, the solitary bulblet, or in some cases 2 to 4 bulblets, develops from a bud on the basal plate on the outside of the fleshy bulb scales but on the inside of the protective covering of the bulb. It is interesting and peculiar that this bulblet develops coincidently with the bulb, while the remainder of the propagation from the basal plate is delayed in its development until the next year, when the old structure disappears and entirely new ones are formed. This precocious bulblet in the second year commonly produces leaves and gives rise to a round bulb, and often it actually produces a small flower. This is especially likely to occur in the robust, vigorous varieties when grown under good conditions of fertility. In such good doers as Mrs. Moon (pl. 2, *F*) it is not at all unusual to have 4 of these bulblets, nor to have as many as 3 of them flower at the same time as the

main bulb. Such condition is also likely to occur with the commercial grower when all the stock of a variety is planted with no turn-off for several years.

CATEGORIES OF BULBS

The tulip bulb as seen in commerce may for convenience be denominated the mature, flowering, or commercial bulb. The best term may be "mature bulb", because at least two categories smaller than this will give a flower.

When a tulip that has flowered is dug in late June to early July it is really a clump of bulbs made up of two or more categories (pl. 3, *A*). To simplify matters it may be said the clump contains 1 mature bulb, already noted, and 1 to 4 small flat ones (pl. 3, *B*). Often there is 1 round bulb in the clump produced from the external bulblet just inside of the protective covering. The small bulbs are flat on one or both sides, and some of them may be large enough to flower the next year, but they commonly require 1 year's growth to come to flowering. The smallest of these bulblets may require 2 years of culture to produce a flower.

When the flat, nonflowering bulbs are planted they round up the first year and are then called round or long-necked bulbs (pl. 4, *B*). The flat slabs that flower make mature bulbs that are usually smaller than those grown from long-necked ones. During the first year of culture of a flat, nonflowering bulb, sometimes also called a slab, but one leaf is produced. If the slab is large and nonflowering and the growth vigorous, this leaf is large and the resulting round bulb will be large and long-necked, for the petiole of the leaf is strong, its dilated base is the bulb coat, and its stalk is the neck. Often these long-necked bulbs are fully as large as mature ones, but they are not considered either mature or merchantable, for they must be grown another year before being put on the market. In other words, a bulb should blossom on the grower's place at least once before it should be offered for sale. In vigorous varieties these long-necked bulbs produce offsets.

To summarize, there are recognized in the tulip the mature bulb, the flat bulb or slab, and the round or long-necked bulb. Small sizes of any shape may be called bulblets, and there is a large variation in size in each category.

SIZE OF FLOWERING BULBS

Barring accidents, a mature tulip bulb, namely, one shown by its form to be the largest bulb produced in a clump that flowered, will flower the next year. It cannot be said that a bulb that flowered the past year will flower again the next, because the bulb that flowered is gone. Each year the bulbs of that year go out of existence and give rise to new ones from the buds on the basal plate.

The size of mature bulbs resulting from the growth from year to year may vary tremendously, owing mainly to climatic and cultural conditions. To keep bulbs up to the normal size for the variety requires cultural conditions equal to those that produced the bulbs in the first place. When tulips are left undug over a season, flowering bulbs will be produced, but they will invariably be smaller than they would have been if dug, reset, and given good culture.

It has been shown that all categories of bulbs—the mature, the flat, or the round—may blossom. The sizes or weights of these may vary greatly, but the size and weight of the "mature" type of bulb may also vary fully as much as the others. To be specific, a single example will suffice. In years gone by, on poor soil poorly fertilized at the Bellingham Station, the bulbs of single early tulip Thomas Moore were no more than 9 cm in circumference. In 1930 the crop dug averaged 13 to 14 cm. The size of the mature bulb that will give a flower in this variety may range from 8 to 15 cm. A good practical commercial size will measure 12 cm.

It is evident that a flowering-size bulb or one that will flower when planted will not necessarily give satisfaction as a commercial bulb. The size of the bulb is the only criterion that gives a reasonable measure of value. This varies with the variety and from year to year with the season and the perfection of culture. There are no sizes established for commercial grades in this country, and only very generally are they observed in commerce; consequently the purchase is made on the integrity of the dealer. Sometimes purchases are made of varieties of tulip bulbs to be of a certain centimeter circumference. Specification of circumference, however, is more common in hyacinths and daffodils than in tulips, where the specification is a general one of first or second size.

RELATION OF BULB SIZES

The relation of the sizes and categories of bulbs remains rather constant in any variety of tulips under similar conditions of culture and disposal. It will vary, however, with methods of culture, fertility, and depth of planting. Poor culture generally stunts growth and reproduction. Very deep setting reduces the number of offspring, and lack of fertility causes a reduction in number, size, and quality.

Possibly the best notion of this subject can be gleaned from an actual record of the relation of sizes in a variety under experimental conditions at the Bellingham Station. The stocks planted contained all the bulbs produced the previous year above 5 cm and below mature size, and yielded as detailed in table 1.

TABLE 1.—*Relation of sizes and categories in stock of Darwin tulip Farncombe Sanders*

Category of bulbs	Size (circumference)	Bulbs	Category of bulbs	Size (circumference)	Bulbs
	Centimeters	*Number*		*Centimeters*	*Number*
Merchantable	15–17	1,800	50 percent rounds	8–10	1,003
90 percent long necks	Above 12	810	90 percent splits	5–8	2,042
75 percent rounds	10–12	1,485			

COUNT, MEASURE, AND WEIGHT OF BULBS

The calibration of tulips in centimeter sizes, their sale by the thousand or multiples thereof, their estimation by weight or measure of planting stock, the variability in size of the different categories

from 3 to 18 cm, and the different characteristics of each variety make the measurement of the grower's materials a rather complicated matter. The practical grower accustomed to handling by count, measure, or calibration can translate one of the measures into the other. However, it requires long experience to enable the new grower to make such translation.

Especially is the matter complicated in this country at the present time when the would-be grower wants to purchase planting stock and has no familiarity with the bulbs except by count. The information required here does not come from books, and it is doubted whether the printed page can familiarize one sufficiently without the practice.

The merchant and the consumer handle bulbs on the basis of a count. The grower soon gets to estimating on the basis of a dry measure; in this country it is a bushel measure, in foreign countries the hectoliter (2.837 bushels). As a matter of fact, the most accurate for any comparison is a measure by weight. We have, therefore, two dry measures, weight and count, as means of estimating tulips. The matter is complicated further by the variability of the sizes adopted and fluctuations in sizes with seasonal and other conditions.

Everyone is surprised at the weight of tulip bulbs, especially after they are cleaned, 2 to 4 weeks after digging. A well-rounded bushel of the bulbs of any of the larger sizes will weigh about as much as a bushel of wheat. The smallest splits are the lightest, but the variation is not great. In the robust Darwins the bushel weight of the large round bulbs may be low, but this is owing to the space held vacant by the long stout necks which are so prevalent.

The greatest weight per unit of measure seems to occur in the cleaned bulbs at the time they are divested of the old coats and the increase removed. Were it practicable to weigh the freshly dug bulbs, the weight would doubtless be greater at that time. As the season advances, especially if the weather is dry, the bulbs lose more in weight than in size. If exposed to high heat and drought for a short period of 10 days or 2 weeks and then stored under cool, moist conditions, they may increase slightly in weight.

The size of merchantable bulbs varies with the variety (pl. 4, *D*). It is influenced by the conditions of culture, the nature of the stock planted, and the suitability of the season. A good bulb of *Tulipa sylvestris* will measure 10 cm, of Allard Pierson 12 cm, and of Farncombe Sanders 15 cm. These figures may be accepted as about the relative sizes, but the actual size may vary each way to a considerable extent.

There does not appear to be any great amount of difference in weight between the various categories or sizes of bulbs. A pound or two per bushel is all except as above noted. The difference in weight of the large- and the small-bulbed varieties is likewise not striking.

The relation of number and measure is dependent on size, of course, but the weight per measure is remarkably constant. The relation of these measurements is well brought out in a series of counts, measurements, and weighings made one summer during an interval of 10 days between cleaning, July 27, and planting, August

7, and shown in table 2. In each case a moderately rounded bushel is the unit of measure. The category of bulb is the merchantable one, the bulb that flowered the previous spring.

TABLE 2.—*Relation of size, weight, and number of tulip bulbs under best growing conditions*

Variety	Weight per bushel	Bulbs per bushel	Size of bulbs	Variety	Weight per bushel	Bulbs per bushel	Size of bulbs
	Pounds	*Number*	*Centimeters*		*Pounds*	*Number*	*Centimeters*
Allard Pierson	59	980	12–15	Inglescombe Yellow	59	900	12–14
Andrea Doria	58	750	12–15	King Harold	59	670	13–16
Antony Roozen	59	480	14–18	McKinley	58	950	12–13
City of Haarlem	58	680	13–15	Mrs. Moon	59	820	12–14
Clara Butt	60	860	13–14	Pride of Haarlem	57	530	14–16
Duchesse de Parme	58	750	12–14	Prince of Austria	58	620	12–14
Europe	57	600	13–16	Professor Rauwenhof	59	500	15–18
Farncombe Sanders	58	520	15–17	Sieraad van Flora	59	650	14–16
Feu Brillant	59	640	15–16	Thomas Moore	59	880	12–14
Giant	58	500	15–16	White Swan	56	1,000	12–14
Grenadier	58	1,160	12–14				

It will be noted in table 2 that the bulbs of Professor Rauwenhof and Antony Roozen were especially large. Doubtless the size here was modified to a considerable extent by the fact that both of these varieties had been worked up from a small amount of stock. In other words, all the stock had been planted back for several years. Naturally this would cause an increase in the size of the merchantable bulbs.

It is interesting to note that the stock of Grenadier was all from bulbs bedded on the grounds of the United States Department of Agriculture at Washington, D. C., the previous season. They were dug as soon as the flowers had faded. A perfect recovery took place in one season's growth at the Bellingham Station. Feu Brillant and Giant were from similarly treated stock the second year previously. All stock of Mrs. Moon was from bulbs similarly treated from the beds the year before. On the other hand, some of these varieties have been grown continuously at the Bellingham Station for the past 20 years. Among the earliest importations were the single early varieties enumerated, together with Allard Pierson, Farncombe Sanders, Sieraad van Flora, Pride of Haarlem, and Clara Butt.

Attention should be called to the exceptional character of these stocks. The bulbs are not only large but heavy and firm. The weights per bushel furnish an excellent check on the quality of the bulbs. It should be understood that such stocks cannot be expected from general marketable materials. These bulbs are considerably larger than the run of the market and would demand a premium. They are larger, heavier, and better than those commonly offered for sale and probably better than the market demands.

DROPPERS

So far as has come to the writer's attention, no one has ever explained satisfactorily either the purpose, function, or morphological significance of the tulip dropper (pl. 4, *A*). The act of dropping is much easier to explain in the squills, nerines, and daffodils. Even

the risers in the snowflakes and snowdrops can be more easily explained structurally. It is not clear why the tulip should drop its bulbs from the level at which they are planted to a lower one. If this were a matter influenced by depth of planting an explanation of it might be devised on that score, but the dropping does not seem to be influenced, at least primarily, by this factor, for it occurs to about the same extent in deep as in shallow plantings.

Dropping is largely a varietal characteristic, some varieties in widely separated groups possessing the habit much more than others. Possibly it is more prevalent in the cottage group as a class, but it was very prevalent in the single earlies at the Bellingham Station in 1930. It is especially prevalent in the wild species. The habit, if it can be so called, is mostly confined to the smaller sizes, for large flowering bulbs as a rule do not form droppers.

The most common occurrence of droppers is in seedlings before they have reached flowering size, and it occurs in all of the groups. There does not seem to be any difference in prevalence of the character in the seedlings of the garden tulip and those of the wild species.

Dropping in the tulip is a very different action from that of the camassia, to select a definite example. Instead of the base of the bulb being pulled down by probably the contractile roots to the lower level through a period of 2 or 3 years, it is the outer coat of the bulb in the tulip that bulges out and grows downward an inch or more. In the base of the tube thus formed the new dropper bulb is formed, completely covered like any other bulb but without roots. Usually only a portion of the growth goes into the dropper, there being a bulb formed also where planted, as though one of the buds developed on the basal plate of the old bulb grew and formed roots and the other migrated to a lower level, or in rare instances to a distance to one side, as with a stolon.

CLASSIFICATION

To classify the garden tulip is a most difficult task which probably will never be accomplished in a botanical sense because of the endless gradations, multiplicity of varieties, and close similarities that exist among its varied elements. A workable artificial arrangement, however, which is most useful, has been devised by the Royal Horticultural Society (*9*). The first main separation is made on the basis of season of flowering. A brief résumé of this arrangement will be useful here.

Section 1. Early flowering.—Dwarf and in full blossom before the end of April.
- *Subsection A.*—Duc van Thol. Very early and but about 2 inches high.
- *Subsection B.*—Singles. Single-flowered varieties (pl. 5, *A*).
- *Subsection C.*—Doubles. Double early varieties.

Section 2. May flowering.—Tall, robust, and mostly flowering after May 1.
- *Subsection A.*—Cottage varieties. All tulips not falling into other classes. All colors and a great variety of shapes.
- *Subsection B.*—Breeders. One color except the base.
  - (1) Dutch breeders. Flower oval or cupped, brown, purple, or red, but sometimes bronze; base white or yellow, but generally stained blue or green to blue-black.
    - *a.* Roses. Pink to red.
    - *b.* Bybloemen. Purple to violet.
    - *c.* Bizarres. Shades of scarlet, bronze, or brown.

A, Single early tulips, Mon Tresor, grown at the Bellingham Station; *B*, planting bulbs in Dutch beds at the Bellingham Station; *C*, planting bulbs with a plow by the row-furrow method at the Bellingham Station.

Section 2. May flowering—Continued
Subsection B.—Breeders—Continued
(2) English breeders. Flower forming one-third to one-half of a hollow ball; base white or yellow without trace of other color.
a. Roses. Rose shades, with white base.
b. Bybloemen. Purple shades, with white base.
c. Bizarres. Brown shades, with yellow base.
(3) Darwins. Lower portion of flower rectangular; segments strong and stems tall; all colors; base black-blue or white.
Darwins are divided into 19 groups on the basis of color.
Subsection C. Broken tulips.—Flowers in which the color appears in the form of stripes on a lighter ground color, generally white or yellow.
(1) Broken Dutch.
(2) Broken English.
(3) Rembrandt (broken Darwins).
(4) Broken cottage.
} Subdivided into roses, bybloemen, and bizarres, like the corresponding breeder groups.
Subsection D. Parrots.—Tulips with laciniate segments.
Subsection E. Doubles.—Double May-flowering tulips.
Section 3. Species.—Wild tulips.
The commercial catalogs recognize other divisions than those shown above. Some of them list the species as botanical tulips.

In the last few years a number of new groups have appeared on the market. They are cataloged as separate classes, but are usually assigned by the Tulip Nomenclature Committee to some group of the May-flowering. All of these new groups are the result of breeding, some of them with the view, apparently in most instances, of bringing better quality into early tulips.

The lily-flowered tulips have resulted from crosses between the Darwins and the cottage tulip Retroflexa, which is looked upon as a lily-flowered tulip. They are all May-flowering and are so included in the above classification. The best-known variety is Sirene.

The triumph tulips have resulted from crosses between early and late tulips. They have not been tried sufficiently on the forcing benches as yet. Probably the best known variety in this country is U. S. A.

The Mendel tulips have resulted from crosses between the tall robust Darwins and the Duc van Thol varieties, for the purpose of implanting more character and size in the early dwarf forcing "Ducs." The group is believed to be a promising one, but little is known about the varieties here. Few of the catalogs agree on the varieties offered.

MULTIPLICITY OF VARIETIES

Much criticism and even condemnation is heard in these days of cooperation, coordination, simplification, and mass production regarding the multiplicity of entities that have been evolved in our horticultural practices. It is true that lists of the offerings of tulip nurseries often look much like a combined list of names from the vocabularies of several nations, and they often take us back into the beginnings of history. It is charged that this multiplicity of names, applied to varieties that differ but slightly among themselves, constitutes an unjustifiable waste and is fostered to befuddle the consumer into the purchase of several varieties when one would serve as well or better.

While there may be a grain of truth in such a charge, in the main it has little foundation. Better charge that in the tulip at least the long list of varieties is necessitated through the nurseryman's lack of confidence in his own judgment regarding which are the best. He often has a fear of not being able to supply a variety for which there may be a demand.

Two agencies have done wonderfully good work in pointing out to the novice the really good things that have been brought to their attention in these long, complicated lists. These are the Royal Horticultural Society's committee (London) reports, and similar awards made by the committee of the Haarlem (Netherlands) shows. All the main nurserymen's lists indicate these awards in their catalogs with the familiar F. C. C. (first-class certificate) or A. M. (award of merit), L. (London), H. (Haarlem). These pronouncements, while not infallible, are excellent guides.

The court of last resort is public use and preference. The public is the final arbiter and its selection from what is offered must be considered the best. But even this is greatly influenced artificially by the energy of individual producers who may develop stocks whose very magnitude and investment literally " put certain varieties over " for a time at least. Investment and clever salesmanship must not be lost sight of in the estimation of values even in ornamental horticulture.

The " trade " may often make egregious errors. Even such concentrated effort as is put forth by the great tulip association of the Netherlands may err in its judgment. This is brought out by the rapid rise in estimation of certain old varieties when some new characteristic is demonstrated. The latent possibilities of a variety have been known to lie dormant for many years until someone accidentally discovered some desirable quality, when there occurred a mad scramble for propagating stock.

There seems to be no safe way to sift out the desirable from the chaff in tulip varieties except through the crucible of public test. As any industry develops, the standard becomes higher and more and more eliminations occur in the producer's testing grounds; but inevitably short-lived varieties find their way onto the market. Of course, as charged, this is economic waste, but no way has been found to prevent it. The best way no doubt is by committee action on behalf of the tulip industry itself.

It is significant that progress in any group is accompanied by a multiplicity of varieties, and this is not peculiar to any people or nation. Witness what has happened to gladiolus in the United States, to daffodils in England, and to tulips in the Netherlands. Within the memory of those living, more than 3,000 varieties of Darwin tulips alone have been put on the market. Such numbers are staggering, but the eliminations have been very rapid. The nursery lists of today do not contain more than 175 varieties of Darwins, but even this number is altogether too great for the prospective grower in this country to undertake to produce. The complications and difficulties become very apparent from a perusal of a list such as that furnished by Wister (*14*), which enumerates 2,500 varieties offered for sale in 1929.

WHAT VARIETIES TO GROW

A grower familiar with market demands, when asked how many varieties one should grow, insisted on six and seemed first inclined to limit his list to William Pitt and William Copland. He later named Allard Pierson, Princess Elisabeth, Lenotre, and Madame Krelage. This is the extreme view of one whose purpose is to furnish bulbs for the greenhouse forcer.

The good forcing varieties of Darwins, on the other hand, make a long list. Besides those listed above, there are Antony Roozen, Bartigon, Clara Butt, Europe, Farncombe Sanders, Herodiade, King George V, King Harold, Petrus Hondius, Pride of Haarlem, Professor Rauwenhof, Sieraad van Flora, Psyche, Victoire d'Oliveira, etc. These are also good bedders.

The Darwins are by far the most popular for all purposes. The single earlies so extensively employed at one time are more popular in Europe than in this country. It is seldom that we see the earliest of all, the Ducs (Duc van Thol). It is believed that the time is fast approaching when the new group of Mendels will come into popularity, giving new varieties with early forcing quality, long stems, and colors as brilliant as the single early tulips.

There is little to be gained from a detailed discussion of a list of the forcers in the single early tulips. Trade lists are a reliable guide. The Duc van Thols are the earliest. In every list will be found Belle Alliance, Brilliant Star, Couleur Cardinal, Fred Moore, Thomas Moore, Ibis, La Reine Maxima, Mon Tresor, Prince of Austria, Vermillon Brillant, and White Hawk.

Of the double earlies, Couronne d'Or, Imperator Rubrorum, Murillo, Peach Blossom, and Schoonoord are most often seen.

The varieties of the other groups are used mainly for bedding, although the breeders and cottage groups contain some good late forcers. Inglescombe Yellow may be the most popular. It is neither desirable nor possible to make a definite recommendation regarding the varieties to grow. Attention has been called to the main forcing sorts, and emphasis must always be placed on these because of the tremendous volume of business done in them.

The lists already presented, together with the roster of varieties still retained at the Bellingham Station (p. 38) from an original accumulation of over 300 varieties, may be useful and of suggestive value to the prospective grower. It represents the preferences of the management. In addition, the station has recently added small lots of 25 of the better, newer varieties of the Darwin, cottage, and breeder groups. These will be evaluated and culled later. Probably not over 5 or 6 will be added to the regular field collection.

RELATIVE VALUE OF VARIETIES

It is not necessary to discuss values in novelties or new varieties of which only limited stocks are available. Here the law of supply and demand and the desire for the new govern as in any other commodity.

Leaving aside entirely the matters of actual merit, popularity, and consequent general demand, there are some varieties that cannot become cheap, because their production cost is relatively high.

The single early tulips in general are a good example of slow increase and the Darwins as a group of excellent performance. The rate of increase in the former is usually about 75 percent by weight, while the latter will give 150 to 200 percent.

This slow increase in the single early group has been a big factor in forcing them to second place in the market. If the new group of Mendels, which are a little earlier still, keep up their good reproductive qualities, the single earlies may be forced out entirely. One has but to compare the clumps of bulbs as dug in Keizerskroon and Mrs. Moon (pl. 4, *C*), for instance, to realize how much easier it is to get up stock of the latter, for, instead of a single slab from Keizerskroon, Mrs. Moon may produce 4 to 6 with bulbs large enough to flower in the axils of the lower leaves besides. Any variety that possesses that indefinable quality of popularity coupled with slow reproduction must remain high-priced. What is likely to happen in the tulip with its plethora of varieties is the gradual disuse of the poor doers.

SOILS AND FERTILIZERS

Tulips are not at all exacting in their soil requirements, for they develop well on both sandy and clay loams, but rather better on the latter. Very light sands and bakey clays, however, should be avoided. A friable loam with a good body is to be preferred. What is known as a strong soil, provided it works easily, on the whole gives the best results. Where such a soil is in good fertility, maximum yields are to be expected.

At the Bellingham Station a rather heavy silt loam underlain by a stiff clay has been employed almost entirely in the tulip trials. The land has but recently been cleared of forest and consequently is rather deficient in fertility. It has required a great deal of effort to bring up humus content and fertility; indeed, it was not until cropping was of long enough duration to allow the rotting of a sod as a preparation for a tulip crop that maximum yields were realized. At present this soil when well fertilized produces really exhibition-quality tulips under field conditions. The stands are perfect, and the quality is what one would expect of exhibition bulbs in exhibition beds and borders.

It is not so easy to handle a crop of tulips on a heavy soil as on a light one, but with present methods of culture it is not difficult to compass the digging, planting, and cultivating on these medium loams. Digging is truly difficult at the Bellingham Station if weeds are allowed to get ahead so that the soil is dried out before the bulbs are dug.

At Arlington Farm the operation for the most part has been on a coarse sand dredged from the Potomac River. It has been difficult to hold sufficient fertility and humus in such a soil. It is noticeable that better results are always secured on the heavier, finer particled portion of the area. But then this is true of all other crops grown here also.

Operations at the Coastal Plain Station at Willard, N. C., have been on the "southern sands", which handle satisfactorily at all times, but it is the climate here rather than the soil that enters into the problem.

The crux of the whole matter of type of soil for tulips was well put by an experienced grower when he advised his listeners to buy tulip bulbs grown on a heavy soil if they could, but not to grow them there. In other words, better crops of bulbs are produced on the heavier loams, but the culture is more difficult. As with most crops, it is the extremes that are to be avoided. Bulbs good enough for any purpose can be produced on either sandy or clay loams.

That tulip bulbs of good quality cannot be produced on infertile soil should be recognized as axiomatic. The numerous failures experienced by the householder who has endeavored to continue his stocks of bulbs year after year are due more to a lack of proper soil fertility than to any other cause. Tulip stocks of practically all varieties "go all to pieces", so to speak, when grown on poor soil year after year.

One thing above all others should be impressed upon the American tulip grower, namely, that cow dung is not the only source of fertility that can safely be used. Indeed, in fertile soil with good cover crops no animal manure may be necessary. Stable manure from which the "fire" has gone seems to be as good as any fertilizer. Sheep manure gives good results, and bone meal cannot be surpassed, but it may be too expensive for liberal use. The nature of the soil will have much to do with the kind of fertility demanded. On heavy silt loams humus is needed to give porosity and tilth and opportunity for percolation of water, which these soils do not naturally have.

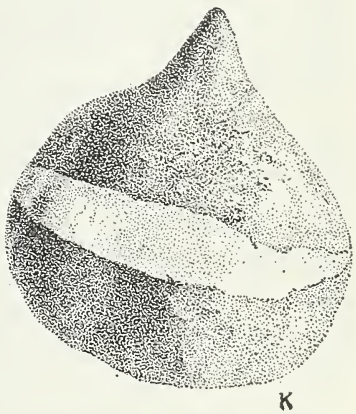


FIGURE 1.—A tulip bulb showing a horizontal gash across the back, resulting from too heavy manuring.

To put the matter tersely, the crop is no more exacting in the nature and the origin of its required fertility than any other farm crop. It demands plenty of fertility but is not particular as to its source, which means, as in other farming operations, that the grower will resort to whatever source is most available to him. Commercial fertilizers can best be supplemented by cover crops and other means of adding humus.

While tulips, like most other bulbous stocks, require good fertility, it is possible to apply too much raw manure for them to give best results. An application of manure too near the time of planting, even though not excessive in quantity, is also likely to cause injury. A heavy application of manure with the removal of some other crop previous to planting the bulbs furnishes the ideal condition for tulips. At the Bellingham Station stable manure has often been applied and disked in over a cover crop of rye turned under in early June preparatory to planting in late August.

Excessive stimulation often manifests itself in the tulip by a large, horizontal gash in the coat across the back of the bulb as well as by excessive size (fig. 1). The bulb seems to expand at too great a rate

for the coat, which is ruptured and slightly wrinkled as well as somewhat thickened over the remainder of the bulb. This is very different from the irregular splitting of the coats due to too great exposure. Here the split has already occurred before the time of digging, and the white, living scales beneath are already somewhat discolored by contact with the soil. Such conditions are likely to occur to some extent when tulips are grown on new, fertile soil, even though it be not heavily fertilized; but in the absence of added manures it is not likely to be serious.

Some varieties are much more susceptible to injury from this cause than others, Cardinal's Hat being very susceptible. In 1919 the stocks of this tulip at the Bellingham Station did not have more than 5 percent of perfect bulb coats in the merchantable sizes when dug. The planting was on newly cleared Whatcom silt loam which had received an application of 12 loads of half-rotted stable manure to the acre in May previous to planting in August, and one small crop of rye turned under. The size of the bulbs under these conditions was very much larger than normal, measuring fully 14 cm as against 9 or 10 cm under low fertility and 11 to 12 cm for the optimum.

It is generally recognized that tulips require sweet soil. In the experimental work of the United States Department of Agriculture this has been taken for granted and no attempt has been made to grow tulips on the forest floor, which was thought to be acid, without the application of lime or bone meal or both. The first application as soon as the land was cleared of forest was 2 tons of ground limestone to the acre. More recently heavy applications of lime-filter refuse from beet-sugar manufacture have been used with evident benefit in the improvement of the tilth of the heavier clays. At the same time the humus content has been built up by sod and cover crops.

PLANTING

The methods of setting the bulbs in the ground may not vary for a great variety of bulbs. As with the daffodil and others, the tulip may be grown with equal facility in rows, matted rows, or beds. The preference of method is dependent entirely on economic and mechanical considerations. The form of planting adapted to one set of conditions is not always the most advantageous for another. It is the purpose here to discuss two main methods, each of which has been employed at the Bellingham Station for several consecutive years.

It must be realized that any method of planting must be judged by its adaptability to a particular method of digging. The two operations depend one upon the other.

THE BED METHOD

The bed method of planting (pl. 5, *B*) is adapted to hand digging. As in all farming operations, rectangular fields are the most desirable for tulip culture. In starting to plant it is well to take a little time and pains to lay off the plot straight and square. Many growers who employ the bed method use permanent stakes at the corners of the beds, but if the grower chooses these may be made temporary, lasting only until the planting is done.

After squaring and laying out the plot, stakes are driven along the sides exactly opposite each other. On each side the intervening spaces between the stakes will be 3 feet for the beds, alternating with 12-, 15-, or 18-inch spaces for the paths. Lines are then stretched on each side of the first bed, and the bed is marked off by inserting a spade to a depth of about 4 inches vertically along the taut line and then drawing it toward the center of the bed. This marks off the 3-foot space across the plot in which the bulbs are to be set in such a way that the sides will be vertical when the soil is removed.

The soil is now shoveled out of the first bed to a depth of 4 or 5 inches, the operation being known as opening up the bed. This finished, the bottom is raked to a level. A wheel hoe may be employed first to start the leveling and to loosen up the bottom. If fertilizer is to be employed it may be cultivated and raked in at this time.

After such preparation a marker is run through, marking the position of the rows and the edges of the bed. These implements are often constructed to mark the center of the row also. Some growers construct a huge rake which when drawn across the bed will mark off 10 rows at once. Men who have become expert at this method of planting use no marker, the bulbs being set accurately enough without any guide.

THE ROW-FURROW METHOD

Plowing in at planting and plowing out at digging of tulip bulbs seems to be in some respects the most advantageous method yet proposed for handling this crop. Planting with a plow by the row-furrow method (pl. 5, *C*) is adapted to digging with a plow. The method is very simple. The most advantageous thing to do is to arrange the planting so as to set the bulbs in each furrow.

At the Bellingham Station tulips and most other bulbs are now planted with a 12-inch stubble moldboard plow with an eccentric hitch, drawn by one horse walking on the land close to the furrow. A strong, steady animal is necessary for the work, but since there is empty travel one way the task is not too hard although the 12-inch plow is crowded to give a 15-inch furrow slice. The soil is well prepared before planting begins, bringing the draft within the capacity of one animal. In the Carolinas a 10-inch plow with one mule is employed for an identical setting.

Some effort has been put into the adaptation of both a 10- and 12-inch moldboard plow for planting tulips. A scratcher in the form of a piece of 2-inch strap iron was attached in the rear as a marker to make a crease in the lower edge of the furrow slice as a guide for setting the bulbs. Another contrivance of a similar nature has been attached to the plow beam to scratch the surface of the land, marking off the next slice (fig. 2).

Such arrangements operate satisfactorily under proper soil conditions. An occasional rock or root, however, destroys alignments by throwing the plow off. In land thoroughly subdued and free from rocks and with a steady horse such arrangements are highly satisfactory. Under such conditions, however, with an exactness of setting not demanded in commercial handling, it has been found desirable to resort to a stretched line for each row, which is at the base of the furrow slice. With a system worked out for handling the line and

other operations, the planting this way can be done very expeditiously.

Plowing for planting is done crosswise of the previous furrows and 6 or 7 inches deep. After a furrow is opened a line is stretched just above the lower edge of the furrow slice. A regular system is employed in all the operations. A stake is set at each end of the row. A crease is made with a triangular-blade hoe along the stretched line, which is then removed, but the marking stakes are left in place as a guide in marking the next row. The bulbs are set and then covered by the next furrow, which at the same time opens the place for another row, which is laid off and planted in the same way.

In all plantings of tulips, as well as daffodils and hyacinths, at the Bellingham Station, a 15-inch row is at present employed. In the North Carolina and South Carolina plantings the same system is used. The Arlington Farm plantings are all in beds.

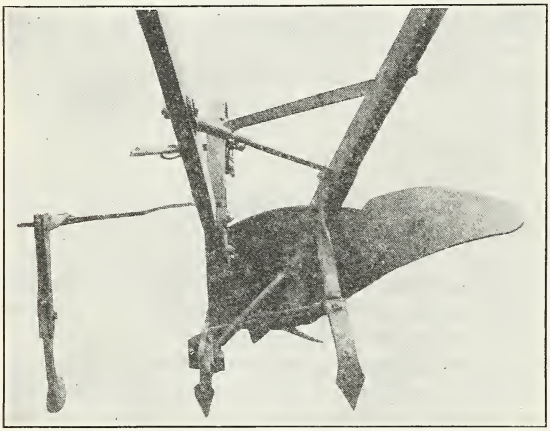


FIGURE 2.—A plow adapted for planting bulbs in rows.

If it is considered desirable to plant in wide rows for horse or tractor cultivation, the planting may be done in the same manner as above described by varying the width of the furrow slice and by leaving one or even two furrows unplanted. When more than a 15-inch space is allowed between rows some growers may resort to a double or matted row planting as is commonly done with daffodils.

In all row planting at the Bellingham Station the single line has been employed because digging is very much facilitated thereby. The objection to the double or matted row method results from the greater difficulty of finding the bulbs at digging time. The wider the planted space the more some of the bulbs are covered with earth when plowed out, and the greater the danger of their not being found by the pickers.

SETTING THE BULBS

The method of setting the bulbs varies with the different sizes. In planting in beds, bulbs above about 8 cm in circumference or sizes that are set upright are most advantageously strewn along the bed from the containers in which they are brought to the field. One man on each side of the bed on his knees sets the bulbs, usually 9 or 11 to a 3-foot row. When planting small sizes, indeed when planting all sizes below about 8 cm or those not set upright, it is advantageous to have small boxes 1 foot square and about 4 inches deep to hold

the bulbs, which are placed from such containers. Sometimes, however, those planted 14 to the row are also strewn along the bed and placed from there.

Bulb setting, while appearing simple, is a job requiring a great deal of dexterity. Boys commonly succeed better at it than men, and some boys are able to place twice as many bulbs as others. With a crew of 2 men to shovel and rake it is desirable to employ 2 or 3 boys to place the bulbs. Two capable boys and 2 men make a good planting crew.

In the "mucking" or shoveling, as in all else in this work, a regular system is followed. Three shovelfuls across the bed, provided the soil is in good tilth and hangs together well, remove sufficient soil to get the required depth. The mucker generally takes a shovelful from the right side, another from the left, and then one from the middle. This method is continued clear across the plot. Each shovelful removed from the bed being opened is placed directly opposite in the bed being covered, the shovelful from the near side of the one going to the far side of the other, and the one from the far side of the one going to the near side of the other. This is decidedly advantageous, for by following such a plan all soil movement is equidistant and uniform.

Usually in the Bureau of Plant Industry experiments the man who rakes down the beds follows the mucker and throws out a small shovelful of earth from each edge of the bed. He works in the partially opened bed and faces in the opposite direction from the regular mucker, doing this work and keeping tally. One of the boys who is planting keeps a record of the number of rows by setting a stake. He calls off the numbers of the rows and of the bulbs planted to the row, which the raker jots down in his planting book each time a change of size or a change of variety is made. This record is simply a skeleton, but with a little computation it gives the total number of bulbs planted and the number of each size. From this record the grower experienced in tulip production in any region may predict with considerable accuracy what can be turned off at the next digging. The row is one of the most useful units of record in this plan of bulb culture. Some record of this nature is considered desirable if not absolutely necessary, not only in experimental but in commercial bulb growing.

In commercial culture where large quantities of a few varieties are grown the record of the planting becomes very much simpler, but some sort of record is necessary. If the plot is square and the beds are all of the same length, the essential record need contain only the dimensions of the plot, the number of bulbs to the row, and the number of beds planted. For instance, if the grower plants 10 beds 50 feet long, since the rows are 6 inches apart there will be 100 rows and 1,100 bulbs to the bed if each row is set with 11 bulbs, and 10 beds will hold 11,000. Computations of this kind are often necessary. Indeed, it is imperative to make such calculations in order to predict the turnoff, for the purpose of sales during the sales season of winter and spring.

Setting the bulbs in the row-furrow method does not differ materially from that of the bed method. The largest sizes are strewn along the furrow from the containers and then set in place by hand.

All work is done from the land side and no tramping is done on the planted ground.

Since the adoption of the row-furrow method of planting, sizing has been very much simplified. The prevailing number of sizes employed is 3, rarely 4. In sizing the bulbs prepared to go into the field it is often more convenient to use 5 sieves, but the lots are usually combined to give sizes from 10 cm up, 8 to 10 cm, and below 8 cm. Rarely is the upper size divided into 10 to 12 cm and 12 cm up, and still less frequently is the lower size divided into 5 to 8 cm and below 5 cm. When the bed system was employed 5 sizes were the rule in planting.

The bulbs are set in single lines. The largest bulbs are put 3 to the foot and the others proportionally closer. All above about 8 cm are set up, and those below 8 cm in circumference are strewn along in a narrow matted row. Sometimes two sizes below 8 cm are employed, one 5 to 8 cm and the other below 5 cm. Both of these sizes are strewn in narrow matted rows, the smaller bulbs often going in as thick as 4 to 6 to the inch.

Most commercial growers practice a much simpler method of distribution of planting material; indeed, the methods employed are even more diverse than with daffodils. The best growers practice setting up of all larger bulbs, but there are some who do no sizing and strew the bulbs along the row from buckets or other containers. So far as the shape of the resulting bulbs is concerned, the placement makes no difference in the tulip, for a new structure always results and that rights itself. It is very doubtful, however, if as good growth results from large bulbs 8 or 10 cm up when they are left in any position in which they happen to fall. The actual difference in result has, so far as known, never been adequately measured.

DEPTH OF PLANTING

The conventional if hackneyed formula of 4 inches of settled soil over the top of the bulb cannot be improved upon for the depth at which to plant tulips under field culture. A little less in heavy soil and an inch deeper in light soil might be added as a corollary. Deeper setting is almost invariably better than a shallower one. Varying the depth according to the size of the bulb is more an academic than a practical matter. It is not usually expedient to make any distinction between the depth at which different sizes are set unless the grower produces but few varieties and separates the large bulbs from the small ones in his fields.

With a large number of varieties on a comparatively small area it has been found impracticable to follow our best judgment in the planting of the smaller sizes. In reality, for perfect results they should be planted about 3 inches deep. They are, however, put down 4 inches or more like all others. The result is that some of the very small ones do not come up. It is only in the rare or expensive varieties that this matters, for they should usually be discarded.

The influence of depth of planting on the number of offsets is very similar in the tulip and the daffodil. Shallow-set bulbs produce more splits than those set at greater depth. For this reason deep planting is advisable when the bulbs are expected to be more or less permanent, as in naturalized plantings. In plantings an inch or

two deeper than the conventional average there may be appreciable although not serious reduction in the size of the bulb produced.

The depth of planting will also have an important relation to the climatic condition where growing occurs. In a warm region planting should be relatively deeper than in a cool one. Tulips, like most bulbs, prefer cool feet, as it were, and a uniformity of moisture and temperature at the roots, which is best secured by depth. Both moisture and temperature are more uniform in a warm region at a depth of 5 or 6 inches than at 2 or 3. As with daffodils, it is considered bad practice to plant shallow and ridge soil over the rows, because of the ready penetration of heat under such conditions.

It is not considered that there may be a great deal of difference in the quality of the bulbs produced at depths of 3 and 5 inches except that under the same conditions there may be a little more splitting at the former depth and slightly smaller bulbs at the latter. They will blossom with equal certainty under both conditions, but the better and more perfect the bulb the stronger and more robust the flower.

Tulips do not require additional covering of soil for protection if planted at ordinary depth. Unless there is danger from heaving, there is no point in putting the bulbs deep for protection.

RECORDS OF PLANTING

As previously stated, some sort of a planting record is desirable. It may be no more than a record of the number of beds or rows and the number of bulbs that are expected to mature to the bed, but the grower who knows what he is doing must have such information.

In tulip culture the grower is constantly dealing in large numbers. At present at the Bellingham Station there are being planted of all sizes close to a quarter of a million bulbs to the acre. Formerly, when the bed method was employed, 350,000 was nearer the average.

It is necessary to be able to arrive at the figures on each variety without actually counting the bulbs. The planting record should give information enough to enable one to get at the totals of various sizes when the figures are needed. Table 3, taken from an old record, shows a form adopted at the Bellingham Station when the bed system of planting was employed.

TABLE 3.—*Form of planting record for bed plantings*

Inventory no.	Variety or species	Rows planted with—				
		11 to row, above 10 cm	14 to row, size 8 cm	21 to row, size 7 cm	35 to row, size 5 cm	50 to row, size under 5 cm
		Number	*Number*	*Number*	*Number*	*Number*
479	Artus	75				
490	Couleur Cramoisi		162	82	86	
493	Duchesse de Parme	151	64	23	32	
327	Faust	5	13	8	8	12
334	General Kohler	29	10	7	4	5
231	Jassi Prince William	19	8	6	4	2
617	*Kaufmanniana*		2	1	3	
526	McKinley	327	184	102	90	104
410	Professor Trelease	22				
418	Rev. H. Ewbank	45	13	10	4	5
538	White Swan	163	62	109	64	95

Adding the figures in a line gives the total number of rows planted to a variety. This can also be obtained by multiplying the number of running feet of a 3-foot bed by 2, since the rows are 6 inches apart. To arrive at the number of bulbs of any size planted, the figure representing the number of rows must be multiplied by the figure in the box head. The total number of bulbs of any variety planted is the sum of the product of the number of rows of each size multiplied by the number of bulbs planted to the row in each size.

The planting record for the row-furrow method of setting is much simpler than for the bed system. However, it is just as important that it be kept, and a system should be worked out by each grower to insure a record that is well-nigh indispensable. That kept at the Bellingham Station, as shown in the accompanying sample (table 4), is suggestive.

TABLE 4.—*Sample planting record of row plantings at the Bellingham Station*

Variety	Rows planted with—			
	180 bulbs to row [1]	207 bulbs to row	305 bulbs to row	532 bulbs to row
	Number	*Number*	*Number*	*Number*
Allard Pierson	5	3	8	8
Feu Brillant	8	2	3	3
Giant	8	2	1	1
Mrs. Moon	4		2	3
Prince of Austria	3	1	1	1

[1] The rows are 42 feet long.

In actual practice the figures in the box heads indicating the number to the row are arrived at when the planting is begun by counting a row or two of each of the sizes. Such figures are then employed during the season, a check count being made occasionally.

CULTIVATION

Tulips are preferably planted in August and September and dug in June and July. They are planted later and dug earlier in the South than in the North. In their culture, therefore, there are two periods when weeds must be taken care of, one in the fall and one in the spring.

The handling of weeds is looked upon as the main function of cultivation of the tulip. Stirring the soil for the purpose of acquiring tilth is not considered necessary, although it is doubtless somewhat beneficial. That very desirable condition should be accomplished by the culture preceding the planting, and the best soil for tulip culture should maintain its tilth and porosity fairly well during the crop period.

Tulips planted in beds leave little opportunity for stirring the soil. The paths may be kept in condition with the wheel hoe, and the beds may be worked with a 1- or 2-tined hoe. The most serviceable tool for removing weeds from the surface of the bed is the scuffle hoe. This is very useful in the fall in removing chickweed and similar plants which thrive in fertile tulip soil. In the spring after

the plants are up it is important that the work be done from the paths so that the planted areas are not stepped on.

In the row-furrow method of handling tulips it is more difficult to take care of the weeds without walking on the planted ground, but it can be done. At present at the Bellingham Station the fall cultivation is done with a spike-tooth harrow pulled over the planting with a tractor by means of a long rope, at right angles to the direction of cultivation. In the absence of such a contrivance a row planting may be kept free of weeds in the fall without trampling by the use of a 16-foot 8-inch board moved along for the workman to stand on in the operation of a scuffle hoe.

One of the newer garden tractors cutting a 3-foot space and allowing the operator to walk on the untilled ground is proving serviceable. This implement is operated only 2 to 3 inches deep, thus avoiding interference with the bulbs, which are set deeper.

After the plants come through in the spring the rows become visible and cultivation may be done with a wheel hoe or a hand tractor. Here stepping on the plants at least is obviated. Some detrimental packing of the soil occurs by every footfall in the interrow space, but this cannot be eliminated entirely.

It is very important, especially with chickweed, to keep the land absolutely clean up to winter when it is too cold for it to grow. If this is done there is little trouble with it in the spring. This is measurably true of many other weeds.

Beds may be kept clean very expeditiously by various forms of specially constructed weeders drawn by two men working in the paths. Such contrivances are very useful in the fall before the plants are up. These implements may take the form of a harrow, a shallow cultivator, weeder knives, etc.

ROGUING

Tulip culture demands alertness on the part of the grower at all times to prevent mixtures. The greater the number of varieties grown the greater the danger that mixtures will occur. Bulbs spill over edges of trays, shelves, or lug boxes; bulblets adhere to the splints of the baskets or remain in the bottom of the bag; and bulbs are picked up in digging from a different variety which has remained in the soil since the previous crop. If these stray bulbs are small, the condition becomes all the worse, because they remain in the stock a year or two before being detected, and by that time a considerable propagation has occurred which contributes still further to complicate matters.

The best time to remove rogues or stray mixtures from a stock is at the time of blossoming. It is for this reason that it is always necessary to let the tulip stocks come to blossom so that the rogues may be better detected. The stray bulbs are gouged out and disposed of. A good tool for roguing is a stout spud with a long, stout blade (pl. 6, *A*). The blade is inserted beside the bulb and the implement is used as a pry to break the roots off and to loosen the bulb for removal.

When bad mixtures occur so that the nonflowering sizes are also mixed it becomes impracticable to true up the stock in the field by

any process of roguing. The only thing to do then is to discard all the bulbs that are too small to flower, and plant the larger sizes, spaced well so that the rogues and all that do not flower can be gouged out easily and discarded. It is quite a task to straighten out a bad mixture in tulip bulbs, but with care it can be done in this way in a single year.

The experienced tulip grower will be able to recognize readily many varieties in a mixture, and can therefore make a separation in the large dry bulbs. The nonflowering sizes, however, do not present distinguishing characteristics so that this can be done. These had better be discarded, the separation, if possible, being made in the merchantable bulbs, and roguing practiced the next season. Unless one or both of the mixed varieties are valuable it is often better to dispose of them as mixed stocks and buy anew.

Someone may ask, "Why not grow the mixture and dispose of it as such?" Any tulip grower will have mixed bulbs enough without growing them as such. There are certain to be more or less of them resulting from each season's operations. There can scarcely be any justification for growing mixtures. The value of the bulbs is halved if not quartered as soon as they are mixed, and it costs just as much to grow them that way.

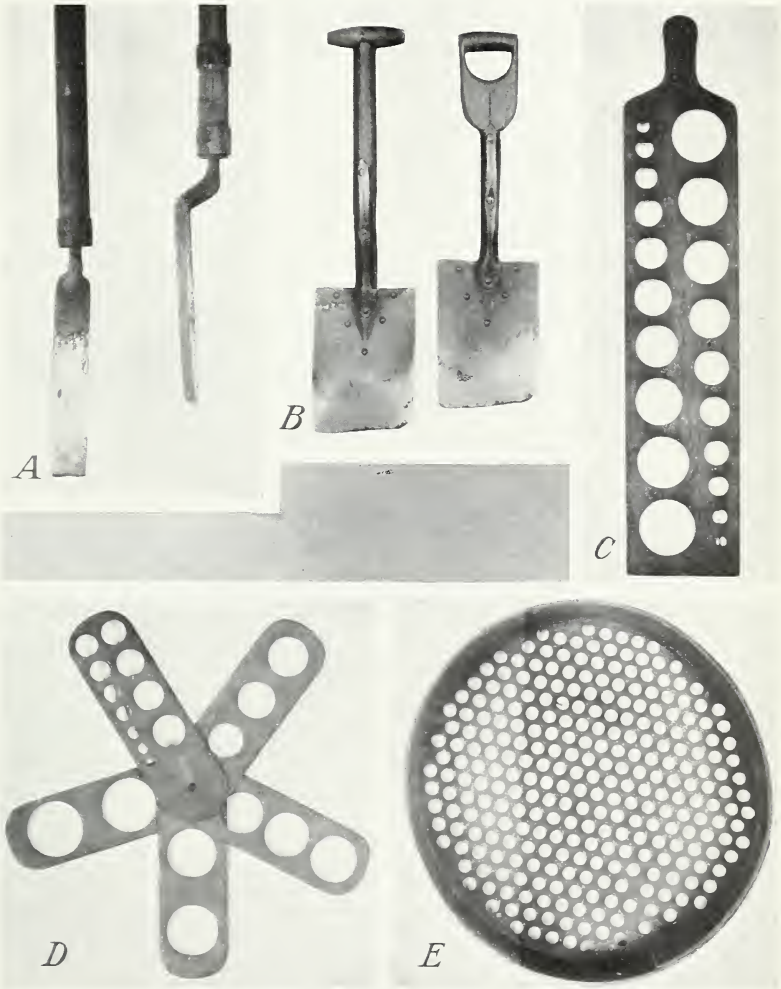
The tulip grower cannot exercise too much care in keeping his stocks true to name and free of mixtures. Absolute trueness to type is of vastly more importance in the stocks used for bedding than in those employed in forcing, but mixtures should not be tolerated for either purpose.

REMOVAL OF FLOWERS

For best results in bulb production, flowers of the tulip should invariably be removed from the plants not later than the early fading. Were it not desirable to let the flowers open for the purpose of truing up the stock, a still greater gain would be secured by the removal of the young buds. It takes plant energy to develop the flower and much more to develop the seed. When seed development is prevented, the energy that would naturally go to its production is diverted to the better growth of the bulb. This is reason enough for the removal of the tulip flowers, but there is at least one other cogent one why they should be taken off—the influence of the fading flowers on the occurrence of "fire" (discussed on p. 56).

The operation of removing the flowers is a simple one (pl. 7, *A*). Fortunately the stem is brittle and does not have to be cut. A handy workman will take the stem between the index and third fingers and thumb and give it a quick or sharp bend, thus breaking it off close to the flower. Operating with both hands he will remove 4 to 6 flowers in each hand before emptying them into containers to be taken out of the field.

At the Bellingham Station this operation is performed as punctually and carefully as planting and digging. As soon as there are signs of fading, the flowers are taken off of the different varieties, the aim being not to allow a single petal to remain on the beds. In Virginia much less care is employed, because the danger from fire is not acute. Commonly the petals drop before the ovaries



Implements used in tulip bulb production: *A*, Spuds used in roguing out stray bulbs; *B*, 2 forms of digging spades; *C*, *D*, 2 forms of bulb calipers; *E*, a bulb sizer with bottom of rawhide.

A, Removing tulip flowers from bulb beds before the petals fall, to prevent fire blight and the formation of seed; *B*, method of digging tulips in Dutch beds, showing hand screens and lug boxes.

are removed, and the latter are then dropped in the paths with no serious consequences from fire. It would be better, of course, to remove the flowers more promptly here also to save plant energy.

DIGGING

The method of lifting tulips will depend on the way they have been planted. So far as known, no machine has yet been developed for accomplishing this job satisfactorily, as with the daffodil. One of two implements—the small spade (pl. 6, *B*) or the plow—is employed, depending on the method of planting.

IN BEDS

In the Dutch-bed method the men work on their knees and take out the bulbs with a small, short-handled spade (pl. 7, *B*). The operation of digging tulips and other stocks by this method, although simple, is capable of being highly developed. The good digger is active, quick, and alert in his movements. He operates his digging tool with a positive movement. He fixes in mind the planting scheme, which enables him to pick up the loosened bulbs and drop them into the tray with no lost motion.

The beds when ready to dig have been hoed off, and there is nothing to indicate the position of the bulbs. The first row in the bed may vary as much as 4 or 5 inches in its position. In starting to dig, therefore, it is necessary simply to find one bulb in the first row. This is done by scratching off the soil over 6 inches or more of the surface until the nose of a bulb or perchance the remains of some of the stems are seen. It is then a simple matter to dig behind the row straight across the bed and remove the bulbs.

The directions for digging appear more complicated than they really are. The operations are simple and are quickly made. The digger always keeps a furrowlike trench in front of him in the position of the last row dug. In starting on a new row he strikes back 6 inches with his spade. The bulbs are located in the middle of this 6-inch space. With a few short, sharp jabs with his spade he removes about 2 inches of the upper layer of soil in a 6-inch strip across the bed. This operation invariably exposes some of the bulbs and visually demonstrates the exact position of the row, the uncovering proceeding from right to left or from left to right across the bed. The digger then begins back on the right or left again. With another thrust of the spade and again pulling the soil and bulbs toward him he loosens the bulbs for a 6- or 8-inch section of the row. The bulbs are then placed in the screen-bottomed trays and the rest of the row is removed in the same way, and so on with the next row. In some cases, especially with large bulbs, the whole row of bulbs is loosened after being uncovered before any of the bulbs are picked up.

The uncovering of the row before loosening the bulbs seems to be advantageous on heavy soils, but on the lighter soils the loosening of the bulbs is accomplished with one movement of the digging tool.

The bulbs come out of the ground for the most part in clumps. The digger lifts the whole clump without any attempt to get it free from soil and places it in the hand screens described elsewhere, pushing the receptacles ahead of him over the bed as he digs.

When the tray is two-thirds full the contents are sifted lightly to remove the loose soil and the bulbs are poured into the lug boxes and taken to the bulb house.

In case the quantity of the variety being dug is large or the bulbs are very wet, it is often advisable to employ a large shaker operated by two men, freeing about a bushel of bulbs from loose soil at one time (pl. 8, *A*).

The bed method of planting is excellent for exact work. It has been employed largely in these investigations because of the greater accuracy possible in the placement and distribution of material. It is not felt that it is so applicable to the use of the commercial grower today in this country, because plow planting is much more economical of labor.

IN PLOWED ROWS

Tulip bulbs that have been plowed in in rows can be advantageously plowed out again at digging time with the same or a larger plow. At the Bellingham Station a 16-inch plow and two horses are employed in digging. It is not necessary to take the tops and weeds off the plants when digging is done with a plow. Often, however, a mower is run over the planting and the tops are raked up and hauled off as a preparation for digging.

It is advisable, when at all possible, to make the last cultivation with a single shovel on the cultivator in order to leave a slight depression between and a slight ridge over the rows. This assists the plowman somewhat in following the rows at digging time.

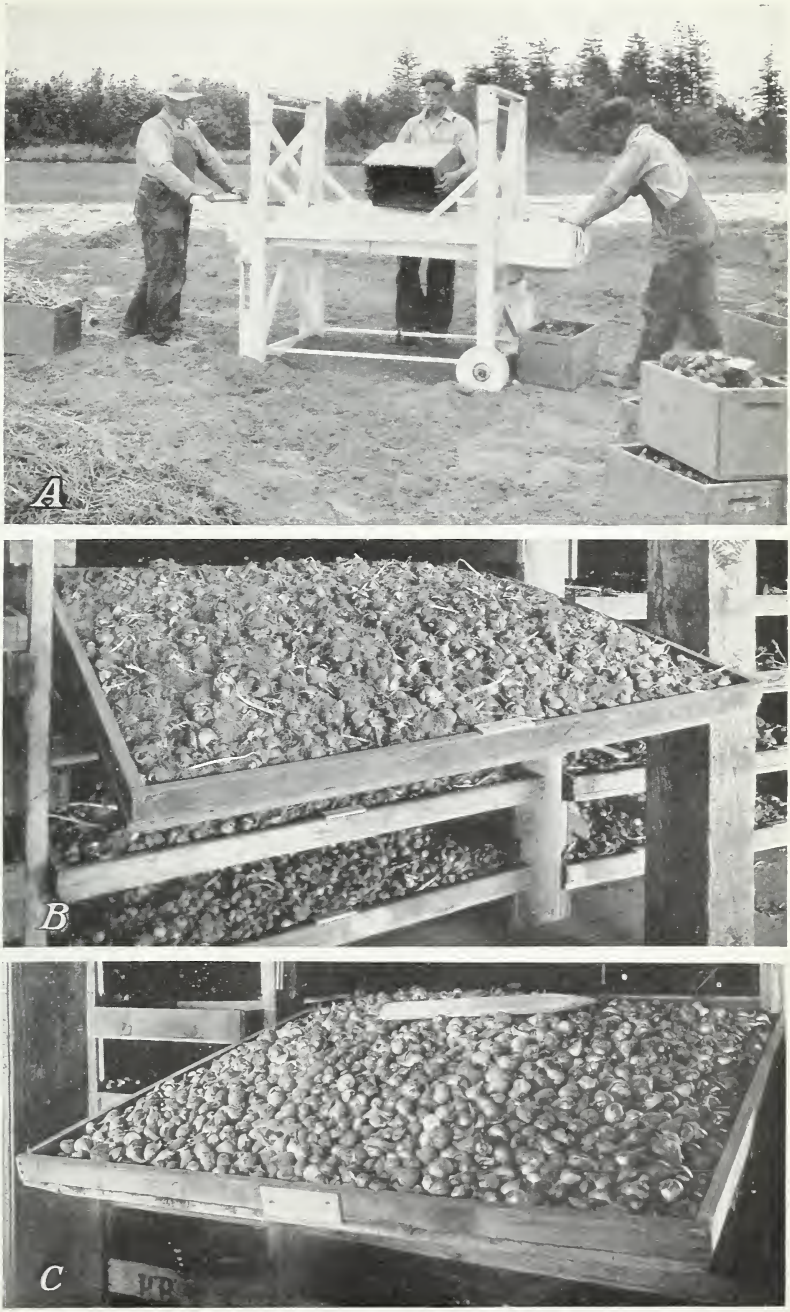
Digging tulips with a plow is a very simple matter. The plowman who has become expert at the job will make the furrow slice just clear the row of bulbs nicely. The bulbs will then be placed on top of the next slice in plain sight as it is turned over. The plow should be run as close to the left and underside of the bulbs as safety will permit, for this greatly facilitates finding them.

When planted in 15-inch rows the entire ground is plowed one way, there being a row of bulbs taken out from each slice. If the area is large, plowing around the land, throwing a furrow each way and going empty across the ends, is possible.

In a planting such as described a good way is to place the lug boxes or preferably baskets at short intervals of 6 feet or so, the bulbs being picked up from the furrow slice and placed (not thrown) in them. There is here great danger of injury from rough handling, as the temptation is to throw the bulbs too far.

The condition of the bulbs as they go into the lug boxes will depend very largely on the condition and nature of the soil. Often the inclusion of a considerable amount of soil is unavoidable. This is especially true on the Whatcom silts of the Bellingham Station. When a suitable quantity of bulbs have been gathered they are put in a screen and the soil is sifted out. On a "clean" soil screening may be omitted.

It is necessary not only to use care to prevent bruising the bulbs in any of these operations, but exposure to the sun and wind must be avoided as much as possible. It is a good plan to pile up the containers and use burlap sacks over the uppermost even for the short time the bulbs are in the field. It is found that even in the weak sunlight of the smoky atmosphere of Puget Sound the bulb coats



A, Large shaker, used to remove soil from about a bushel of bulbs at one time; *B*, tray of tulip bulbs as loaded for drying, pulled out of the rack for inspection; *C*, tray of McKinley single early tulip bulbs cleaned and partly withdrawn from the rack for inspection.

of the freshly dug bulbs will crack with 30 minutes' exposure. As soon as they have been screened the bulbs are placed on the trays or shelves of the bulb house in layers about 4 inches deep.

WHEN TO DIG

Tulips should be dug when they are ripe, but it is not always easy to judge of the most suitable degree of ripeness. It is remarkable how often this question is asked, and still more remarkable how difficult it is to give a short answer.

In general it may be said that tulip bulbs should be dug before they are quite ripe. Prompt digging as soon as they are fit is one of the cardinal points in their handling. As soon as the thin brown coat is fully colored it begins to disintegrate, which seems rather peculiar on first thought, nevertheless it seems to be true that the coat is best preserved when the bulbs are dug slightly prematurely. It is not considered injurious to the bulb to dig before full and complete maturity.

The best outward indication of maturity of the tulip is the yellowing of the tops. Generally, this is taken as the time for lifting or digging, but this is not always an infallible indication. It may apply fairly well to the single earlies, but some of the Darwins and late varieties may need to stand until the tops are quite dead. In some cases where the tops go down prematurely because of drought or inroads of the tulip fire another factor is introduced. The tops may be dead for some time before the bulbs are ready to dig.

The best way to determine when bulbs are ready to be lifted is by an examination of the bulbs themselves. Before maturity they are white and gradually turn color as they ripen. Of course the perfectly white bulbs may turn brown after digging, but time for this transformation should be allowed in the soil. At the Bellingham Station digging takes place when one-fourth to one-half of the surface of the bulb has turned color. This is perfectly safe, and the coloring continues on the shelves; but it is not well to dig until the coat has begun to turn color.

The practical bulb grower does not dig his tulip varieties in rotation, but lifts each one when it is ready and without delay. The digging may continue over a period of 3 weeks.

Small bulbs that have not flowered mature considerably earlier than full-sized stock. There is an advantage, therefore, in segregating the nonflowering sizes so that they may be dug a week or 10 days earlier. In the Bellingham plantings the segregation is made into sizes at planting time, but on account of the comparatively small quantity of a variety the sizes follow each other in rotation under the varietal name with the result that the young stock is always slightly overripe at digging time. However, the round bulbs are usually heavier coated and therefore less subject to injury through disintegration of their covering than the flowering sizes.

A tulip bulb, whether large or small, and whether developed in 5 or 10 months, if properly handled, is capable of becoming an independent plant whose quality seems to be directly proportional to the size that has been attained. A surprising development of the new bulbs has taken place by the time the plants come through the ground in the spring. By the time the blossoms fade, the first half of May,

all the new bulbs are well developed and the most advanced are usually large enough to produce a flower the next year, but are slightly below the average in size. This is not all. Tulip bulbs held cold (36° F.) all winter will be found by May to have made bulbs as large as filberts without any top growth. These seem also to be as good for planting as bulbs of similar size brought to full maturity in the soil.

Bedded tulips are usually gouged out as soon as the flowers fade, to give room for summer bedding plants. If the varieties are expensive, or if a grower desires to secure cheap planting stock rather than planting stock to give a turn-off the next year, such bulbs can be saved for that purpose. With good field culture for 1 year the stock will be normal again.

Bedded tulip bulbs of first quality not removed from the beds until the flowers are completely faded may be employed for ornamental purposes a second year with a large measure of satisfaction. This plan has actually been put into practice in recent years in the city of Washington. Tulip bulbs from the Bellingham Station bedded on the grounds of the Department of Agriculture are used a second year for bedding purposes by another Government function whose funds do not permit the purchase of new bulbs. The plan, inaugurated on account of stringent necessity, has been so satisfactory that it is likely to become a permanent practice. However, as a general thing this sort of double use is not to be recommended, for its success is predicated on three factors not always possible of control. The bulbs planted must be of prime quality, the bed conditions must be conducive to the best possible development, and the summer storage must preserve the bulbs without deterioration. Usually the bulbs are so cheap that it does not pay either the private individual or park superintendent to attempt to hold the stocks over.

The use of bedded bulbs as planting stock for the production of bedding bulbs after 1 or more years of good culture can be recommended unhesitatingly. The practice has been uniformly successful in the experience of the Bureau of Plant Industry for the past 10 years. No less than 2 dozen varieties bedded on the Department of Agriculture grounds at Washington, D. C., have been sent to the Bellingham Station and Arlington Farm without a single instance of poor results. The practice has had the advantage in this case of an estimate on the value and condition of the stock while bedded and the roguing of an occasional broken individual in the case of imported varieties.

HANDLING AND CURING THE BULBS

Tulip bulbs should go from the field to the bulb house and be poured out of the containers onto trays or shelves in thin layers (4 inches) without delay. It is risky to leave them in the lug boxes overnight because heating is very likely to take place.

The word "curing" as applied to tulip bulbs as well as to other flowering bulbous stocks is largely a misnomer. Curing bulbs is an artificial and unnatural process necessitated by commercial handling, and not a process required by the stocks themselves. The more closely, therefore, the conditions of nature can be imitated during the time the bulbs are out of the ground the better they will be preserved. It

should be constantly borne in mind that we are dealing with plants whose natural environment is the soil, the multitudinous influences of which are very difficult to imitate. This curing consists simply in drying the bulb clumps as they come from the ground until the old coats appear dry to the touch. The bulbs are dried sufficiently so that mold will not develop. The whole process amounts to striking a balance between an excessive moisture that will allow the development of molds and other decomposition organisms, on the one hand, and too great a desiccation on the other.

Given control of the two factors ventilation and light, it is a comparatively simple matter to cure tulip bulbs properly in any region in this country that is adapted to growing them. Dry conditions of late summer and fall are important assets in the curing of tulip bulbs both in and out of the ground.

MANAGEMENT OF THE BULB HOUSE

If the bulb house is filled rapidly and to its capacity there is a proportionately large amount of moisture to be evaporated and got rid of at one time. Usually the bulbs come into the house rather slowly, and some may be dry and ready to clean before the last of the crop is dug. It is therefore advantageous to fill first one portion of the compartment devoted to tulips, so that the ventilation can be lessened at one end and put on fully where more needed.

On Puget Sound the ventilating doors of the bulb house are usually left open or partly so during the greater part of the day and are closed at night. This treatment will be all the more emphasized if the location is near the coast. Even 3 or 4 miles inland less ventilation will be required. The advantage of the closed house at night is to assist in keeping up the temperature, which in this location is low.

It should be remembered that tulip bulbs must not dry out rapidly. The curing process is not simply one of evaporating the moisture, but this moisture evaporation is the physically obvious indication of very complicated life processes taking place in the bulbs on the shelves. If the bulbs are dug at the proper time to preserve the coats they will not have turned color completely when brought into the bulb house. In this condition they should not become dried out and ready to handle in much less than 2 weeks. A little longer time does no injury, and 10 days might be enough.

The directions that can be given for handling bulbs in the bulb house are necessarily very general. The grower must learn the work by doing. He must learn to know his stocks and to know what they need from day to day. This does not mean that the matter is at all complicated. It is simple when compared with handling vegetatively vigorous plants in the greenhouse. Indeed, for 3 years at the Bellingham Station 300,000 tulips, besides the complement of planting stock, were cured annually with little control of ventilation. Operations have been carried on in an open shed with fair success, but it was necessary to clean the bulbs as quickly as possible and then smother them with buckwheat hulls or old sacks in order to protect them from excessive desiccation and light.

EQUIPMENT AND FIXTURES

The house in which tulips are handled should have provision for the perfect control of both ventilation and light. The heat conditions will be subject to the natural fluctuations of the temperature of the region, but the bulbs will keep better if they are placed in a cool basement after they are dry and cleaned.

The conventional structure for this purpose has not less than one-third of its wall space made up of partly glazed doors extending from the floor nearly or quite to the ceiling. The interior arrangement is such as to admit of storing the bulbs in layers 4 to 5 inches deep. This is accomplished by the use of stationary shelving or trays.

The shelves may be built in, about 15 inches apart and 2½ feet wide. They may be constructed 5 feet wide with a partition in the center, thus making two shelves back to back, as it were. Between these double rows of shelves are alleyways about 3 feet wide to permit getting the bulbs in and out.

Trays are stacked in racks made to receive them (pl. 8, *B*). They have an advantage over the shelves in that they can be placed closer together, thus economizing storage space; but they have the disadvantage of requiring a greater width of alley than the solid shelf. The alleyways must be wide enough to permit carrying through them the trays loaded with bulbs.

The size of the tray will depend upon convenience. Those employed at the Bellingham Station are 4 feet square with a 2- to 2½-inch edge. They are constructed of matched lumber to prevent even the smallest bulbs from falling through and thus mixing stocks. This is a 2-man tray. A few trays, however, 2 by 4 feet, can be handled by 1 man. Some prefer a tray about 3 feet square, which can be handled by 1 man. Daffodil trays in common use have lath or wire screen bottoms and are commonly made to stack. It is doubtful whether such bottoms are as suitable for handling tulips as trays with solid bottoms, because of a too free circulation of air.

THE BULBS IN STORAGE

All periods in the life history of a living organism are important, but the storage period is especially so in the cycle of development of the commercial tulip bulb, for it is not a difficult matter to ruin a bulb for commercial purposes. The stocks when dug may be of good quality, but if improperly handled in storage they may be ruined in appearance, reduced in keeping and shipping quality, and injured for forcing.

The condition of the bulbs will vary greatly when they come into the bulb house, depending on the nature of the soil in which they are grown and its moisture content at digging. At the Bellingham Station and in the Pacific Northwest generally there is fortunately a condition admirably adapted to tulip maturity. The rains cease about the middle of June, and the tulip bulbs are ready to dig in late June and early July. They therefore come out of ground that is drying although it may not be dry, and the bulbs are in a condition that permits them to surface-dry in a short time. They require less ventilation than if they came out of the ground wet, and their dry-

ing should be retarded rather than hastened. In light sandy soil from which the bulbs are dug dry, the effort should be to prevent desiccation from the outset.

After the husks are dry to the touch through the mass of bulbs on the tray or shelf, ventilation should be strictly curtailed. There should be no drafts of air, and light should be decidedly subdued. The object of all of this is to preserve the outer brown coat, so important to the appearance of the bulbs and still more important in preventing abrasion and desiccation of the delicate tissues beneath. Strong light alone will crack the coats, so it is quite necessary that both drafts of air and strong light be excluded from the bulb-storage house as soon as the stocks are dry enough so they will not mold.

There is very often the additional factor of heat to be considered, but in the Bellingham situation this is not a factor, for the temperature in an ordinarily well-aerated building is never so high that it needs to be reduced. In a region having warm summers, however, the matter of temperature needs consideration. In the vicinity of Washington, D. C., tulips dug as soon as they are ripe are usually out of the ground before the hottest weather has arrived. They may remain in an ordinary building during the summer, but are much better dried and cleaned in such a building and then stored in a darkened and cool basement.

CHANGES AFTER DIGGING

The behavior of tulip bulbs when transferred from the field to the storage house is well brought out in the accompanying tabulation, which is based on 1 rounded bushel of bulbs of Darwin tulip Psyche, taken from cloddy soil after the land had given up most of its moisture. The soil was of a heavy black crumbly nature, and consequently there were included with the bulbs at digging time some small clods that would not pass through a ⅜-inch screen. On a fine sandy loam this would not be included and the gross weight on digging would be less.

	Pounds
Weight at digging, July 11, 1930	61½
Weight at cleaning, July 22, 1930	58½
Loss of weight by evaporation	3
Weight of clean bulbs	49½
Weight of debris, clods, etc	9

The most important item here is the one relating to the loss of weight in the bulb house in the short period of 11 days. It represents the evaporation during this short time. Sixty-one and one-half pounds, or 1 bushel of green bulbs, lost 3 pounds of moisture in 11 days' time during a very dry season in a well-aerated building with no drafts of air and from which light was largely excluded.

SHELF REQUIREMENT

The area of shelf space needed in the bulb house will vary greatly with conditions. The main factors that influence it are the moisture content of the bulbs when placed in storage, the control of ventilation in the house, and the general atmospheric conditions. Under conditions that make for rapid desiccation the bulbs may be piled higher

and consequently require less room. As a rule, tulip bulbs can go on the shelves 4 to 5 inches deep.

In order to have a reliable conception of the bulb-house space, it is necessary to take into account its relation to field space and to the number and weight of bulbs. As a concrete example, the following data give useful information on actual operations and show these relations:

In 1919 the merchantable turn-off of Cardinal's Hat was 22,000 bulbs, a number large enough to afford trustworthy figures of the space actually employed for handling. The bulbs were dry when dug, and of prime quality. Their coats, though, were somewhat cracked, and they were piled higher than usual to get added protection from atmospheric influences. In addition there were 70,000 planting-stock bulbs, of which it may be said that about 11,000 were below 5 cm in circumference and were discarded later at planting time. The salable bulbs weighed 1,620 pounds and the planting stock 1,120 pounds, a total weight of 2,740 pounds. They were grown in 3,384 rows in 37⅔ beds 45 feet long, occupying about one-fifth of an acre. These bulbs required 260 square feet of shelf room in the bulb house.

The drier the situation the less shelf room is required for a given quantity of bulbs. Indeed, it is found that the new location of these experiments on Puget Sound requires less shelf room for a given area of ground planted than did the old one, although the yield is greater. This is due to drier, better-drained soils, and to the better atmospheric conditions that exist farther back from the coast.

In handling an acre of tulips in 1920 the bulbs were brought into the house in rotation. The shelf room occupied may be accepted as rather more than is necessary to hold a good crop of these bulbs for the proper curing of stock on such an area at one time under commercial conditions. In practice, when digging is not continuous or rapid, it is possible to clean and condense the stock on the shelves and thus occupy some of the shelf space more than once.

A total of 180 trays 4 feet square held the bulbs from 1 acre for curing in 1920. This in round numbers is 2,880 square feet of shelving, which was ample for a 1-acre crop. It is thought that 2,000 to 2,500 feet of shelving would be sufficient for an acre of tulips under commercial conditions where comparatively large lots of few varieties are handled.

It will be seen that over twice as much shelf space proportionally was used in the 1920 season in handling an acre as was required the year before for a single variety, Cardinal's Hat, on solid shelves. Solid shelving, although not so handy, may be more heavily loaded per square foot than trays. It is also to be noted that in 1919 the crop was much drier when dug, and this particular variety really could have been cleaned with but a few days of drying.

CLEANING THE BULBS

The breaking apart of the propagation and the removal of the old husks and debris from the tulip bulbs after they dry on the shelves is known as cleaning. The work is done preferably as soon as the bulbs are dry, which is about 2 weeks after digging. This operation in its initial stages is strictly handwork. As practiced at the Bellingham Station it involves the removal of the bulbs from the shelves to a long table around which the workers operate.

The workman cleans a small space on the table in front of him, then pulls a handful or two of bulbs from the pile and spreads them

out one deep. The clumps are picked up individually, the propagation consisting of 1 to 5 or 6 small bulbs, which usually loosen and fall as the old base is broken off. Occasionally, however, an extra movement is required to cause these to separate. The small bulbs are allowed to fall on the table, but the large ones are placed in containers, returned to the shelves, and covered with burlap to prevent the coats from cracking. As soon as the clear space in front has been worked over, the small bulbs and debris are pushed to one side and another lot of fresh bulbs is pulled down and spread out from the pile on the table until all the material has been worked over.

At intervals the small bulbs and debris on the table are shoveled off into containers and taken to a revamped grain-fanning mill which screens out the dirt and winnows out the husks, leaving the bulbs clean.

Cleaning tulips requires quick movements and nimble fingers. Women and young people are well adapted to it, but it is not a child's job. The breaking off of the old base when the bulbs have been dug at the proper time requires strength in the fingers which children do not have.

The importance of taking out the large bulbs by hand at cleaning time should be stressed because of the ease with which they are bruised. It is not good practice to put these through the fanning mill. As they are handled, a special container called a scoop is employed and the bulbs are placed therein and not dropped or thrown in. This sort of container, especially when padded, assists greatly in the protection of the bulbs, not only when they are being loaded but on unloading into lug boxes as well. The bulbs should no more be dropped into pails or baskets a foot high than should eggs.

After the cleaning, both the large bulbs (pl. 8, *C*) and the small sizes are returned to the shelves, but in much deeper layers than when they came from the field. The small bulbs should not be piled as high as the large ones, because the mass is not so well aerated and there may be danger of molding. Unless the ventilation is under very good control, it is well to cover the large bulbs with burlap after a day or two until they are packed for shipment. Under some conditions it will save some labor if the large bulbs are put in sacks for shipment as soon as they are cleaned, but unless well dried before cleaning there is danger of molding.

NEED OF CAREFUL HANDLING

Care should be the watchword at all times in the handling of tulips. Dropping bulbs into containers, throwing them from one place to another, or letting them drop from shovels or scoops should not be tolerated.

The larger the bulbs and the better they are grown the greater necessity there is for care in handling them. It is the large bulbs that are likely to soften from bruising. A slight bruise under the outer skin from rough handling at digging time may not be visible at all, but may cause these large bulbs to soften so that they must be thrown out about cleaning time. Others may soften later and will require culling at planting or packing time.

The large-bulb varieties are more subject to handling injury than those having small bulbs. The varieties that rot rather badly at

the Bellingham Station are City of Haarlem, Pride of Haarlem, Professor Rauwenhof, Edmee, Madame Krelage, Europe, and Victoire d'Oliveira. As high as 5 percent of some of these rotted at times from no other cause than bruising in the shakers, containers, or on the shelves. This kind of injury has commonly occurred before the stocks reach the bulb-house shelves, but it does not become noticeable until cleaning time.

A very pronounced case of bruising injury occurred in 1930 with Darwin tulip Antony Roozen. The stock of this variety had been worked up from a few bulbs, all of it having been planted back each season for several years. The stock in 1930 numbered nearly 2,000 very large merchantable sizes. They were really wonderful bulbs. The soft bulbs thrown out at cleaning and packing time amounted to 3 or 4 percent.

These spoiled stocks are referred to as soft bulbs. They change color slightly and are soft and watery, presenting a touch very different from a healthy bulb. If poorly aerated they may mold and shrink to little but a shell, but under good aeration they become chalky and hard.

CLEANING THE FIELDS

Some bulbs are always missed in the digging, whatever method is adopted. Some means must be used to get rid of them the next season, for they persist almost indefinitely and are to be looked upon as weeds thereafter. Even if the land is put in a meadow after a tulip crop, it still becomes necessary to get rid of these missed bulbs, for when the cycle of a tulip crop comes around again, the bulbs will be there to cause a mixture of stocks.

Some tulip varieties are more difficult to get out of the ground without misses than others. In general, varieties making a large number of bulblets, many of which are small, are more difficult to dig clean than those producing large splits. A poor crop with a thin stand is more likely to be poorly dug than a good crop with a uniform thick stand. Such a variety as Mrs. Moon is particularly annoying, for it often produces aerial stem bulblets 10 cm in circumference in abundance. These are certain to be largely left in the field, and many of them will grow.

At the Bellingham Station the tulip plots are disked, harrowed, and picked after the digging, to remove as many of the missed bulbs as possible by the middle of September. An attempt was made at one time to seed the plots to rye and dig out the bulbs in the spring. This practice gets rid of the bulbs quite effectively, but is objectionable for economic reasons. At present all bulbs possible are picked up after the cultural implements in summer. The land is then plowed about 15 inches deep and seeded to timothy and clover. In the spring the tulips that come up are cut off 3 or 4 inches below the surface with a spud such as is used for roguing. Often it is necessary to go over the plots twice in a season and sometimes again the second year.

If for any reason a bad job of digging was done, such methods are too laborious and it is then more economical to resort to plowing. The most advantageous time to do this is in early spring when the plants are only about 2 inches high. If they are turned under deeply at this time few will survive. If this treatment is followed by a

cultivated crop, the clean-up may be made doubly effective. The plowing must be done early before the leaf growth has become advanced, for from then on the bud for the next season's bulb grows very rapidly and will persist if not destroyed before it has attained size enough to live over summer.

YIELD

What is a good crop of tulips? What profit can be made from their culture? These are both important questions difficult to answer. Profits are so uncertain in any crop that it may be well not to attempt to get down to dollars and cents, but to visualize if possible what takes place when a crop of tulips is planted and harvested, or what is put in and what is taken out again at the harvesting.

At the Bellingham Station the lands are laid off into approximately half-acre blocks 50 feet wide and 400 feet long. The actual planted area is slightly less than these dimensions, and therefore slightly less than one-half acre is actually covered with bulbs. The shortage is not great, however. In the discussion that follows, this area will be referred to as a half acre.

The bulbs in the record that follows were set in single lines across the plot 12 to 13 inches apart. The largest bulbs were never set less than 3 to the foot, and the smaller sizes proportionally closer. The smallest size, mostly 5 to 7 cm, were strewn in 25 or more to the foot in a narrow matted row.

In 1929 there were planted in this half acre 3,632 pounds of bulbs, or a total of 111,500 bulbs of all sizes, according to methods of estimation which are always conservative. The best measure of quantity here is that of weight, but the estimated number of bulbs is useful, although unless complicated by a detailed description of the sizes planted it may be very misleading, and if so complicated may be too involved to be visualized. By way of explanation it may be pointed out that rather more large bulbs were put in than would occur in the average commercial planting, but the difference was not great if the commercial planting be kept up in quality. Aside from the planting back of all the bulbs in several varieties in which stocks were being increased, the material returned to the soil did not differ from that of any commercial tulip bulb farm. With very few exceptions bulbs of all categories were planted in each variety. The number of bulbs that had flowered varied greatly, owing to the turning off of a different set of varieties on alternate years. In many lots there were few beyond round bulbs planted.

The planting weights were taken as the bulbs were sized preparatory to being taken into the field, in season very comparable with the weighing made every year at that time. The figures for the total yields, however, are more conveniently made at the time the bulbs are cleaned. The figures of yield, therefore, are made a week or 10 days earlier than the planting date.

The tonnage yield is one thing; the turn-off of merchantable bulbs is another and a very different thing, although they are closely associated. With a good comparability between the categories planted, the proportion of the different classes of bulbs will be constant, for the ratio of the development is quite uniform in each variety.

The total turn-off of merchantable bulbs from the half acre in 1930 was 35,000. This figure does not represent the total production of merchantable stock, but simply the actual turn-off. Large bulbs were planted back in considerable quantity in a number of varieties in order to insure the requisite quantity to turn off in certain varieties the next year.

In the planting of 1930 but very little stock below 5 cm was utilized. It is not known what this would have amounted to, but probably not over 4 or 5 bushels. There were 5 or 6 bushels of planting stock of varieties which it was decided to discard that were not used. So from the digging of that year there was enough material turned off, had the Bellingham Station been a commercial concern, to provide for the sale of 35,000 merchantable bulbs, to plant back an equivalent area, and to dispose of a total of 10 to 12 bushels of planting stock. This last item possibly should be reduced to 5 or 6 bushels, for it is questionable whether it is economy to plant the small bulbs which pass a 5 cm screen. The yields of the individual varieties are shown in table 5.

TABLE 5.—*Yield of tulips by varieties at the Bellingham Station in 1930*

Variety or species	Planted in 1929	Dug in 1930	Variety or species	Planted in 1929	Dug in 1930
	Pounds	*Pounds*		*Pounds*	*Pounds*
Allard Pierson	217	510	Madame Krelage	128	250
Andrea Doria	123	369	Mons. S. Mottet	6	11
Antony Roozen	110	281	Mon Tresor	19	37
Bacchus	70	150	Mrs. Moon	175	440
Belle Alliance	32	72	Paris	64	175
Boadecia	9	22	Petrus Hondius	35	82
Boule de Neige	29	50	Pride of Haarlem	187	462
Chrysolora	21	38	Prince of Austria	57	100
City of Haarlem	143	432	Princess Juliana	74	196
Clara Butt	62	195	Professor Rauwenhof	84	205
Dasystemon	5½	8	Proserpine	26	61
De Wet	15	26	Psyche	159	371
Duchesse de Parme	45	87	Retroflexa	9	18
Edmee	82	195	Sieraad van Flora	124	287
Europe	105	293	Spathulata	17	41
Farncombe Sanders	138	389	*Sylvestris*	9	14
Feu Brillant	186	448	The Bishop	32	66
Fragrans	6	11	The Sultan	32	95
Giant	144	299	Thomas Moore	60	137
Greigi	1	1	Turenne	89	212
Grenadier	85	238	*Turkestanica*	2½	2¾
Helen Eakin	1	2	Valentin	112	201
Inglescombe Yellow	42	179	Victoire d'Oliveira	67	192
Kaufmanniana	3½	3	Walter T. Ware	22	35
Keizerskroon	42	78	Washington	87	182
King Harold	60	177	White Swan	58	120
McKinley	86	130	Zwanenburg	9	23

A word of caution may be desirable here. The commercial tulip yield in foreign bulb districts is only 35,000 to 40,000 merchantable bulbs to the acre, and 70,000 is about the maximum production. It is not at all likely that the commercial yield in this country will exceed that in foreign lands. Indeed, it may be considerably less, since the tendency here is to adopt a wide row, thus reducing the population. However, with intensive methods and intelligent handling a yield of 70,000 bulbs to the acre is not difficult to maintain in the Puget Sound area. The employment of sod land, safe rotation, abundant fertility, ample drainage, and care in culture and handling should attain it. Such a yield has been maintained at the Bellingham Station for the last 5 consecutive years.

PACKING AND SHIPPING THE BULBS

Many methods are employed in packing tulips for shipment, the main requisite being an aerated pack which at the same time protects the bulbs from abrasion and undue exposure. For short shipments and small packages, aeration need not be considered after the bulbs have dried sufficiently, but large quantities must be aerated lest they should heat, sweat, and mold.

The most satisfactory shipments are made in perforated paper sacks holding a dozen to 250 or more bulbs, like those used with imported stocks (pl. 9, *A*). These sacks are packed in slatted crates holding 15 to 20. The bulbs may be packed both with and without buckwheat or other chaff between them, and apparently with success in either case. Often the bulbs of the cheaper sorts from the Netherlands placed loose in slatted crates arrive in fairly good condition. The better and more expensive sorts, however, are always packed with greater care.

Sacks for large shipments are not always readily obtainable in this country, especially in a strength of stock that is required. The Bureau of Plant Industry has used a square-bottom sack of sterling leather paper having a bursting strength of about 55 pounds, but about 75 pounds would be better, and this is the kind mostly used by foreign growers. Since there is some moisture present in the bulbs, it is important that the sack be well glued. These containers for large shipments are about 5 by 9 by 19 inches, and when filled hold 130 to 350 bulbs. The top is folded, so that a tie once around each way with a stout cord holds. At times cloth sacks holding 1 peck have been used with satisfaction, but there is objection to cloth for the reason that the aeration is not so good as with the perforated paper sack.

The style of crate used by the Bureau of Plant Industry has varied from year to year, and of course that used by commercial growers will vary until a tulip business develops in some locality where cooperation and teamwork will standardize operations and materials. The crates now employed are about two-thirds the capacity of the largest Dutch crates, but it is believed that these are too heavy (pl. 9, *B*). They measure 20 inches deep, 27 inches wide, and 29 inches long, inside measurements, hold 18 of the large paper sacks, and weigh (gross) when well packed about 375 pounds each. Such a crate is strictly for wholesale business, and even for that a series of smaller sizes should be on hand. They should be designed to accommodate a definite number of sacks, fitting as tightly as possible and without undue pressure.

The wholesale dealer in tulip stocks desires above all things to be relieved of the burden of unnecessary handling, counting, and repacking. The pack must be such that it will hold without deterioration for a reasonable length of time. Each package (sack) should be plainly marked with the name of the variety and the number of bulbs.

While it is common for the tulip cases to remain unopened for weeks after arriving at destination, it is believed that the safer plan is to unpack the crates even if nothing more is done than to turn the packages over and return them to the larger container. The sacks, however, are much better left unopened until sold; indeed, the less

the bulbs are disturbed and exposed to the air the better, provided no deterioration is taking place. Late in the season when the bulbs have thoroughly dried, pouring them out of the sacks is sure to remove many of the coats which by this time are almost certain to have cracked a great deal. The less they are handled after packing for shipment the better, for each time it is done some coats are lost.

IMPLEMENTS

The ordinary farm tillage implements must be employed efficiently in order to grow tulips well. The plow, the subsoiler, the harrow, the clod smasher, and the float are especially important. These are the implements of good farming, and it is good farming upon which tulip production is dependent. There are a few simple special contrivances that are needed to save time in tulip culture.

The spud or roguing tool (pl. 6, *A*).—A leaf from an old automobile spring shaped to a shank and driven through a ferrule into a stout handle makes a very convenient tool for removing stray bulbs from a planting.

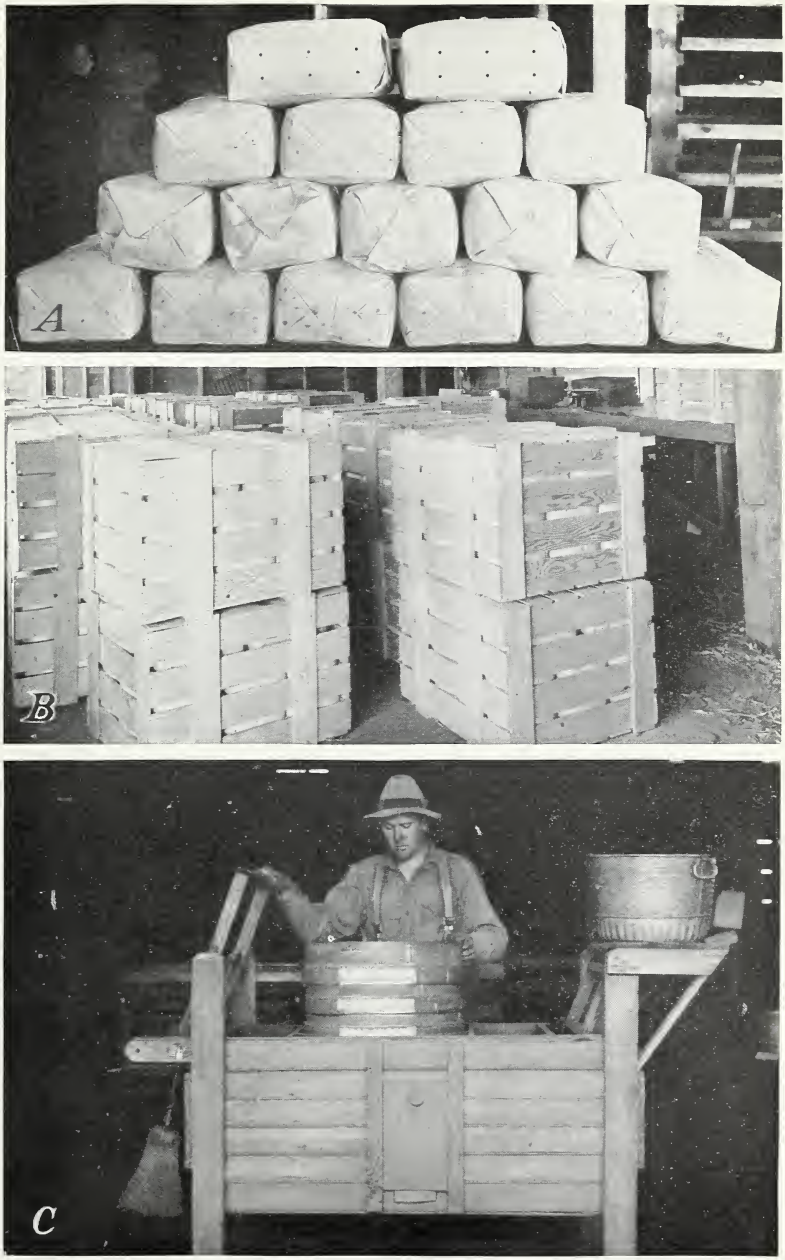
Sizers.—Sizers are of various forms and capacities and are employed mainly for the separation of the planting stock into different sizes for the better distribution of the crop on the ground. The most common form of tulip sizer consists of one or more nesting hoop sieves (pl. 6, *E*) with bottoms perforated with openings of graduated sizes. They are nested in order, with the smallest openings below and the largest above. Each sieve catches bulbs too big to pass its openings and which have passed the one above. The bulbs caught by a sieve take its centimeter designation and that of the sieve above it. For instance, if the two sieves in question are 8 cm above and 6 cm below, the bulbs are designated as 6–8 cm bulbs.

Some growers have used screen wire of different meshes for their sieves. These are satisfactory for some bulbs, but are too likely to injure tulips. A much better bottom is made of perforated laminated wood. But the best of all is perforated pigskin, as is commonly employed in the foreign bulb-growing districts.

More than two of these sieves nested make too cumbersome and heavy a load to be shaken in the hands; consequently some sort of a carrier must be provided for operating or agitating the nest. Sometimes a simple carrier is provided, into which the nest of sieves is fastened and suspended to the ceiling by three wires or chains. A better carrier is a horizontal one suspended in a frame and so swung as to be easily oscillated through a small arc (pl. 9, *C*). Such a contrivance is built with a hopper under it to receive the dirt, debris, and small bulbs that pass the last sieve.

In large operations a sizer built in the form of a cylinder made up of sections with different perforations, on much the same principle as the well-known gravel sizer, is employed. These machines are expensive and are adapted for large operations only. However, the grower with only 3 or 4 acres of tulips intensively planted handles enough material to justify their use (fig. 3).

Shaker screens.—Various devices are used to remove the soil adhering to the bulbs at digging time. The simplest of these is an inclined plane whose floor is of ¼- or ⅜-inch wire mesh over which



A, Tulip bulbs packed in perforated paper sacks; *B*, sacks of bulbs packed tightly in crates; *C*, 3 sieves nested on a carrier which may be vigorously shaken by hand; the use of 3 sieves gives 4 sizes, the 1 below 5 cm in this case falling into the pit below and being removed through the sliding door.

the bulbs roll from top to bottom, thereby ridding themselves of the adhering soil particles.

Another way is to build a box 30 inches wide, 6 feet long, and 6 or 8 inches deep, with a similar screen bottom. This is balanced on a piece of inch pipe supported on two uprights. As one end is raised and lowered the bulbs roll from one end to the other, thus removing the soil.

A better way is to support the screen-bottom box on swivels in a stout frame (pl. 8, *A*). There should be handholds at either end by means of which two men by the proper jerking motion given the box slide the bushel of bulbs, which is a normal load, from one end to the other. If the screen wire terminates 12 inches short of one end and a tube of fabric is fastened over it, the bulbs may be dropped automatically into containers placed on the ground.

For small quantities, and especially for hand digging, small screen-bottom boxes 15 by 24 inches and 4 inches deep are very serviceable.

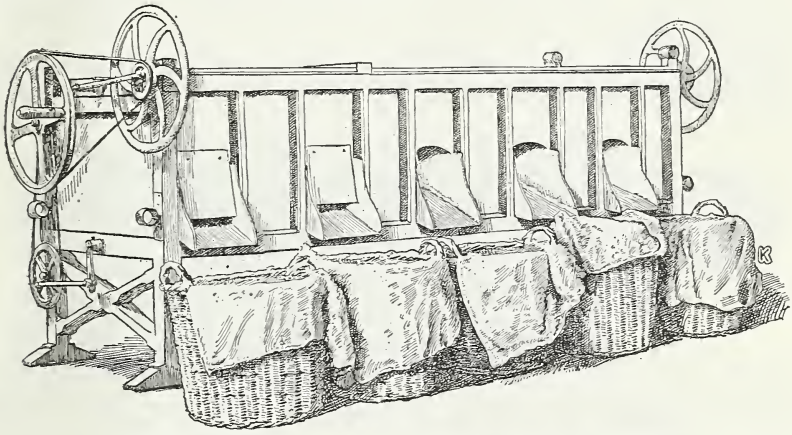


FIGURE 3.—A type of bulb sizer used in large operations in the Netherlands. Commonly the machine is operated by electric power.

These are employed as receptacles for the bulbs as dug. When half full they are shaken slightly to remove the loose soil before the bulbs go on the bulb-house shelves.

Commercial sizers are manufactured in the Netherlands. The most popular seems to be that shown in figure 3, in which the bulbs pass over a series of agitated, perforated planes of gradually increasing perforations. The bulbs passing through the perforations in the plane fall into separate compartments. Thus a separation is possible into 7 or 8 sizes. These are expensive machines, applicable to extensive operations.

Digging spades (pl. 6, *B*).—While there are no tools on the market adapted to bulb digging, it is possible to remodel commercial implements to serve the purpose. A boy's spade cut down to about 22 to 24 inches over all makes a very serviceable tool. This is done by setting the **D** handle lower down, or by simply cutting off the handle at the proper length and attaching a crosspiece in the form of a **T** for a handhold.

The main requirements for this tool are that the blade be flat and the handle as nearly straight as possible. This spade is not used to lift the soil, but simply to pull it toward the workman. To do this it is necessary to have the blade flat on account of the small space between the rows; otherwise there is greater danger of cutting the bulbs.

Occasionally one finds on the markets what is known as an auto spade. It is an imported tool which is easily adapted to bulb-digging purposes. When the handle is cut down 4 inches it makes one of the best digging spades known.

Planting boxes.—It is necessary to have in the field at planting time small, light, shallow boxes holding 6 to 8 quarts of bulbs. These are especially useful in planting the smaller sizes, since it is not profitable to strew them along the beds from the lug boxes, as is done with the larger bulbs. They may be made of ⅜- and ½-inch light wood and may be 12 by 12 inches and 4 or 5 inches deep, inside measurements. These should be smooth and light. A pail is not well adapted to this purpose because of its depth. A light, shallow vessel is needed.

Scoops.—Scoops are essentially pouring vessels, but they are also very useful on the tables at cleaning time to receive the bulbs as

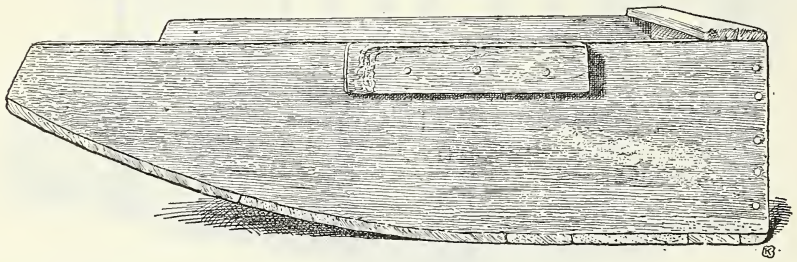


FIGURE 4.—A scoop that is essentially a pouring vessel, used to load closely set shelves and to make careful transfer of bulbs from one place to another.

cleaned. They are made as shown in figure 4, are useful at cleaning time in various sizes from a peck to a half bushel, and the large ones are employed for loading closely set shelves.

Hand scoops are used like the grocer's scoops to take up the dry bulbs. They are best made with flat bottoms and straight, nearly vertical sides and backs, and with stout handles. When properly made and carefully used there is nothing better for handling tulip bulbs in bulk.

Calipers.—These instruments are used to measure individual bulbs. One form consists of a thin piece of veneered wood in which are bored holes varying usually from 3 to 23 cm in circumference (pl. 6, *C*). A more convenient form is put up in 5 veneered strips about 3½ by 12 inches, superimposed upon each other and fastened together so as to open like a fan (pl. 6, *D*).

Another instrument is made in the form of a machinist's caliper, but with wide beam and much longer jaws. On the beam are two scales, one reading in centimeters in circumference and the other in centimeters in diameter.

A 3-foot steel tape marked in centimeters on one side and inches on the other is carried by most stationers and dealers in artists' supplies. This makes a very convenient bulb caliper.

Blowers.—The blower used in this work is a grain-fanning mill with the wind, sieves, and padding so adjusted as to accommodate the handling of planting stock of bulbs. The machine is adjusted so that the bulbs pass over a screen as they leave the hopper and then fall through a strong draft onto another longer screen. These operations remove soil, pebbles, small clods, and debris.

Lug boxes.—The lug boxes used need not be essentially different from the fruit lug box, and they are used in the same way in hauling bulbs from the field at harvest time and back to the field again at planting time. They should, of course, be as light as is consistent with the necessary strength. Those in use at the Bellingham Station are made to hold 1 bushel. At Arlington Farm the ordinary splint fruit basket is used. These are light, convenient, and with care last 2 or 3 years.

Separators (fig. 5).—When the bulbs are stored on long shelves it is necessary to have an adjustable partition between varieties. These partitions can be made of 1 by 4 inch lumber to fit crosswise of the shelves. Pieces of 1 by 2 by 4 inches can be mortised into the lower side of this partition at each end to hold it upright. Partitions may

FIGURE 5.—A separator, used on solid shelves or trays between two varieties to prevent their running together.

be made for dividing trays in the same way. Such separators may also be used on the cleaning table when it is convenient to clean more than one variety at a time.

Markers.—A revolving drum of slats which mark off the rows in the bed system of planting is very useful. This must be home-made and may be constructed to mark off rows of any width as well as the edges and the center of the bed. One is shown in the distance in plate 5, *B*.

LABOR

Operations peculiar to tulip culture will be discussed here mainly, with simply a reference to operations that are common to other crops, in order that the prospective grower may be able to visualize the labor requirement of a tulip crop raised on the basis of culture consistent with the expectation of good production.

The planting of an acre of tulips at the Bellingham Station is looked upon as a job requiring 5 days' time. The days are 8 hours long, and the crew consists of 3 men and 2 boys. Six such days are ample for putting the bulbs in the ground on the basis of lining out each row and with a record of the planting. Besides this it takes half of one man's time for the same period to get the stocks ready. This labor cost should be reduced in commercial operations where the hours are longer and the exactitude of the practice here is not demanded.

The labor cost of digging an acre of tulips at the station is practically the same as that required for planting. Six days is ample time, if everything works smoothly, to get out an acre of bulbs with a plow and to put them on the bulb-house shelves. Indeed, the job is often finished in 5 days. While commercial practice may make some gain on the planting record, it is not believed that it will gain very materially on the digging except in the matter of longer hours, provided, of course, the same method of planting and digging is employed and the same density of crop is maintained.

Cleaning tulips is looked upon at the station as a tiresome task, rather dreaded by both men and management. The past season 2 men and a boy were employed 5½ days cleaning the bulbs from a half-acre planting. This included taking the bulbs off the shelves, taking out the large bulbs by hand, cleaning the smaller sizes with a fanning mill, restoring all to the shelves, and taking the gross weight of about 60 varieties separately. It is believed that this labor cost could be greatly reduced in commercial performance. It is more than likely that the field crew may not be employed at this work and that it could be more advantageously done in large operations as a piece job.

The labor incident to getting the cleaned bulbs on the market will vary greatly, depending on the nature of the sales. If the business is by retail, both the labor and the expense are greatly increased. If the bulbs are packed for bulk shipment, one good man will pack and crate the bulbs from an acre in about 4 days.

The items listed above are those that are peculiar to the tulip. There are other chargeable expenditures, of course, which are exactly comparable to other farm practices and which need only to be mentioned. They are common to many crops. The cost of cultivation will be very similar to the cost of keeping weeds down in a crop of beets, carrots, or onions. The fertilizer required will be from 1,200 to 2,000 pounds and should be high-grade. Land preparation cost will be approximately the same as for good truck farming.

BULB VERSUS CUT-FLOWER PRODUCTION

The production of merchantable tulip bulbs from plants that have furnished blossoms for sale is a most difficult task. The better the stocks are grown the better will be the bulbs, of course. It is conceivable that a good grower may cut the flowers and still produce better bulbs than the poor grower who has not sold flowers, but this is begging the question, for the fact remains that the removal of the flowers in a way that will be acceptable to the market reduces the production of bulbs.

The market demands long stems on tulips. Some markets are satisfied with a cut below the upper stem leaf in the Darwins and similar sorts. This is the shortest that will be accepted. Were it possible to dispose of the blossoms cut above the first leaf, little if any injury would be done. In many of the Darwins the stem above the first leaf is long enough to make a decorative cut, with greenery of some other origin. This sort of cut is feasible for home use, but the market usually will not take it. In short, the tulip bulb grower should not expect to sell flowers and bulbs from the same plants.

TULIPS IN BEDS AND BORDERS

Next to the greenhouse consumption of tulip bulbs, their use in beds and borders is the most extensive. Tremendous quantities are employed in this way, and there is opportunity for a great extension of this kind of decorative planting. However, there are plenty of communities where tulips for decorative purposes are well adapted that seldom see them. Commonly, all that is necessary to create an interest is a few specimen plantings or a little advertising by a horticultural club or other civic organization.

Formal bedding in tulips as in many other plants has certain requirements or conditions which it is desirable to fulfill. The distribution of the plants should be regular. They may be in almost any sort of geometrical design or irregularly placed so long as they are approximately equidistant so as to secure a uniform and solid effect. To get equality of performance the bulbs planted must be of uniformly good quality, of one size, and from one production. Again, it is important that they be planted at uniform depth. Failing in these features, there is much lost in the general effect at flowering time. Perfect uniformity of performance cannot be attained with bulbs of different sizes nor from those planted at different depths. Even beds crowned too high in the middle may develop enough slower on one side to interfere with the uniformity of blossoming, and bulbs mixed from light and heavy soil or from different regions seldom blossom together.

The form of the planting may be adapted to the situation. Circles, squares, rectangles, long beds, or more complicated designs have their places and uses. Single long lines are not as pleasing as a wider planting of 4 or 5 bulbs, or, better, groups at intervals. In the herbaceous or shrubby border the bold grouping of separate varieties is most pleasing. Plenty of strong groups separated by just enough of the greenery of other plants to set them off are the most charming.

It is scarcely necessary to enumerate varieties adapted to bedding and border uses, because one will seldom make a serious mistake in the selection of varieties if the proper attention is paid to the short characterizations that accompany nearly all commercial lists. This is not saying that there are no tulips poorly adapted to bedding, but they are comparatively few. For formal bedding the single earlies are most admirable. Their brilliant colors cannot be surpassed. Although not particularly popular at present, it may well be that the pendulum will swing back in time and bring to the fore again such fine things as Prince of Austria and its sport, De Wet, Duchesse de Parme, Fred Moore, Thomas Moore, Vermillon Brillant, Mon Tresor, McKinley, White Hawk, Brilliant Star, etc., to say nothing of La Reine Maxima and Keizerskroon.

The Darwins, cottage, and breeders are the real bedders of today. One seldom uses the single earlies in the shrubby border, although among the lower herbaceous perennials which do not overtop them before blossoming they are capital. In such a situation the Darwins, cottage, and breeders are particularly appealing. To one who will use the landscape as his canvas, these classes of tulips serve admirably as his paints. The danger of clashes in color is rather remote. They are possible but occur infrequently. This has always

seemed to the writer to be particularly true of the Darwins, for clashes among them are rare.

The present fashion is in solid colors for either beds or borders. One color in a place is preferred in tulips. It is practically impossible to secure a mixture that gives satisfaction, although it is quite possible to make one. When made, it requires a planting of much greater magnitude than ordinary to be effective. The most satisfactory mixture of tulips the writer has ever seen was one made up of 150 varieties of Darwins. Mass plantings an eighth of an acre in extent of such a mixture were most interesting. Small beds were not so pleasing. But such mixtures are not practical. The bulbs are generally not wanted in the quantities that will produce desirable effects, and the grower cannot afford to produce mixed bulbs which sell for half price.

Tulip beds and borders may be wonderfully enhanced in their beauty by a proper background of shrubbery or trees, but these backgrounds should not be too close. The immediate proximity of strong shrubs or trees is not a suitable place to grow scarcely anything, even though the soils are thoroughly prepared and suitable fertility is incorporated before planting. Trees and shrubs draw too strongly on the water supply close to their bases, thus endangering bedding plants. Sufficient space should intervene to insure that the beds are not deprived of their moisture, and care should be taken to see that there is suitable fertility, especially if the bulbs are to be preserved for future use.

As previously stated, uniformity of stature, of blossoming, density of planting, and coloration are prime requisites in bedding tulips. These factors may not be so important in the border, where the masses are small. Although purposely refraining from listing varieties suitable for bedding, it seems desirable to call attention to one especially, for it seems to the writer to possess rare merits. This is Darwin tulip Paris, seldom seen, and not often offered for sale. It is rather difficult to handle because of its thin skin, which is easily abraded. This variety has the rare characteristic of opening wide and closing again many times before it fades. Darwin tulip The Sultan also possesses wonderful bedding form, but not so much can be said for its color.

The wonderful effect of the tulip displays in Dutch beds at the Bellingham Station where 50 to 60 varieties are sometimes planted on a half acre suggests that the Dutch-bed method of arrangement may have application in large ornamental plantings (pl. 10, *A*). However, this method would require quite large plots to be effective. It may be said that no ornamental arrangement is more spectacular than our alternate beds of single earlies or Darwins, assembled as they are with reference to the time of blossoming. However, a comparable desirable effect is produced by alternating blocks of 10 or 12 rows of a variety.

Having an absorbing interest in the plants themselves, the writer may be pardoned for preferring to grow tulips for tulips' sake. He prefers them planted by themselves, in masses extensive enough and thick enough so that their own charms suffice for the vista. When planted 6 by 6 or even 8 by 8 inches in good rich soil they cover the ground perfectly with their rich, handsome foliage, which is the best of ground cover for the floral display. When, however, the tulip is

A, Tulips in experimental culture, showing a wealth of blossom in a massed bed planting; *B*, single early tulip Thomas Moore, forced in a fern pan; *C*, Darwin tulip Edouard Andre, 8 bulbs forced in a fern pan.

The progeny of a bulb of single early tulip Cottage Maid, after being undisturbed in grass for 20 years.

planted in bold clumps in the herbaceous or shrubby border, their associations become important.

For carpeting a bulb bed, pansies, violets, lobelia, and sweet alyssum are capital. Good effects can often be produced by interplanting tulips with crocus, the small squills, or glory-of-the-snow. Possibly the greatest apostle of carpeting plants for tulip beds is Rockwell (*8*), and a good case he makes of it.

THE TULIP NATURALIZED

It is not often that the tulip is referred to as a suitable item for naturalizing. The bulb is particularly subject to inroads from rodents, and consequently it disappears in a short while. As the available food supply is exhausted the flowers become dwarfed, it is true, but they are still tulip flowers, are attractive, and add color, character, and beauty to the landscape in which they are placed.

At times tulips behave admirably under naturalized conditions. While the writer prefers a soil moderately fertile for naturalizing the tulip bulb, he would prefer not to plant on a soil loaded up with humus, which begets earthworms, which attract moles, which make runways for mice.

Several instances of successful naturalizing of tulips in quite stiff clay have been experienced. It is not intended to convey the idea that tulips will not grow better on a fertile, friable loam, but their enemies are more likely to find them there. Moles and mice do not burrow successfully in stiff or gravelly soils, consequently the tulips planted there escape them.

At the Bellingham Station some years ago a large measure of failure was experienced on a certain half-acre plot planted to tulips, due to the heavy, plastic, and cloddy nature of the soil. The condition was so bad that it was vowed not to plant the plot to tulips again; so it was seeded to timothy, and the bulbs missed in digging were allowed to remain. For 8 years this bit of meadow was a beautiful array of varicolored tulips. Practically all the varieties grown at the station persisted equally well. The field was mowed each year the last half of June, rather earlier than digging time for tulips, but still there was always good blossom in this field.

Tulips of some of the popular single early varieties have persisted for 10 years in the writer's lawn, which is handled much as a meadow. It is a heavy clay fill in which mice and moles have not worked since the first heavy manuring has worn out.

A prominent citizen of Bellingham, Wash., C. T. Canfield, a few years ago dug for the writer's edification the progeny of a bulb of Cottage Maid tulip which he planted 20 years before (pl. 11). It was set in heavy clay. There had been one to several blossoms each season, and when dug the clump had made 64 bulbs of all sizes, 4 or 5 large enough to blossom the next year.

These examples are enough to show the adaptability of the tulip to culture on a let-alone basis, in spite of the fact that it is not usually considered in this category. In a planting for such a purpose it would be better to plant deeply; 6 inches to the top of the bulb in a clay soil might be sufficient, but 10 inches would be none too deep in a loose, sandy soil. There are records of plantings persisting indefinitely when set 14 inches deep.

THE TULIP IN HOUSE PLANTINGS

Little time need be given to detailing the ways, the locations, and the positions in which tulips are suitable in the embellishment of the home and grounds. The conventional ways and arrangements of their employment for decorating the home premises are familiar.

Beds, borders, path edgings, foundation shield, beneath deciduous trees, between shrubs, border of shrubbery or woodland, around, among, and beneath the trees in the kitchen orchard, and even the rock garden and the window box are all suitable places to be embellished by some form of the tulip. Indeed, it is seldom out of place in any position from the inside of the window to the farthest nook in the garden or in the field.

The culture of the tulip in the home may be considered from two main viewpoints, one being that of the householder who is interested entirely in the decorative effect of the tulip planting, and the other the viewpoint of one who is interested also in the tulip itself, its life history, its structure, its methods of reproduction, and its welfare in dormancy. The handling of the tulip for home decoration will vary, depending upon which of these two interests prevails.

The grower with the first viewpoint needs little information beyond that relating to the preparation of soil, the method of planting, and where to purchase his bulbs, for his main consideration is appearances. He will gouge out the tulips and discard them as soon as the blossoms have faded, to give space for summer bedding plants.

This viewpoint is without doubt the most prevalent, but the plant students in the garden fraternity are also a legion. Doubtless the best method of procedure for the vast majority of busy city and suburban dwellers is to purchase new bulbs each year, or at most every 2 years. Tulip bulbs are so cheap and so easily secured in good quality that it is vastly better for the average householder to depend on his seedsman for a new supply each year. The cost will be but a few dollars, and the bulbs will be of better quality than he could hope to produce, since he may have neither taste, time, nor space for the task. It is believed that the average man, unless he is of that rapidly developing amateur gardener class, will be more successful if he buys new tulip bulbs each season.

The amateur gardener, the plantsman, needs information about all phases of tulip handling about the home. He must realize that the tulip is a gross feeder and must be supplied with an abundance of plant food if the bulbs are to be preserved. Animal manures are generally safe enough to apply, provided they are well rotted and do not come within 4 to 6 inches of the bulbs. Horse manure especially should be thoroughly rotted and well beyond the heating stage. Bone meal at the rate of 12 to 14 pounds to the square rod, well mixed with the soil, is always safe, or a similar quantity of a commercial formula found adapted to potato culture in the locality will answer admirably. The directions given for commercial culture can be easily adapted to the operations of the amateur.

The tulip is perfectly hardy and in the greater part of the country does not need winter protection. In moist sections also the beds are better for having no litter on them after growth begins. A mulch, however, is always in order and valuable, but decaying strawy material is safer off the beds after the plants are up.

The bulbs will be better developed if left in the beds until the tops are well yellowed. If they must be gotten out of the way as soon as the flowers have faded they can be lifted carefully and heeled in in some out-of-the-way place to mature and then be taken up again and stored.

Tulip bulbs should not be sunned. They may be dried in thin layers in the shade of trees for an hour or two. Small quantities may then be stored in peach baskets on a shelf in an airy situation without drafts in a cellar. When the outer coats are dry to the touch, the bulbs should be covered with sacks to keep off both drafts of air and light, or placed in paper bags with the top twisted.

In warm regions like Virginia, for instance, early October is a good time to plant, and September in a cooler region. In general, the earlier one plants after the heat of summer has subsided a little the better. The bulb clumps are broken apart at this time and a separation is made into two sizes, one to go back into the beds and the other into a nursery, where they should receive similar culture to the large bulbs.

If the bulbs planted are of first-class quality and the digging has taken place as soon as the flowers have faded, the bulbs may be used the next year with moderate satisfaction. In order to behave normally they should be grown under good cultural conditions for another year before being used again for bedding. They should then be in prime condition.

FORCING

The forcing of tulip bulbs does not differ essentially from the same process as applied to daffodils and hyacinths, the main difference being that tulips must be brought along somewhat slower than the daffodil and much slower than the early hyacinth.

The flowering of the bulbs inside is generally done in flats (shallow boxes) about 4 inches deep, or in pans or pots (pl. 10, *B*, *C*). Any good garden soil will serve the purpose admirably, although somewhat finer flowers may be had from well-prepared composted soil. The exigencies of market demands, however, require a cheapened product, and the soil is one place where an economy is effected. During the development of the flower the old bulb is drawn on largely, and inflorescence can be produced with little or no plant food. While it is admitted that better flowers are produced in a rich soil, often little attention is paid to fertility.

After the bulbs are "flatted up" (planted) it is the usual practice to wet the soil thoroughly and set them away to root (fig. 6). Commonly the advice is given to withhold water for a time until root growth starts, and doubtless a nicety of handling would demand this, but the general practice is to soak the soil and let it drain as it will.

There is a variety of practices in rooting tulips. Some growers still use the pit system, in which the flats are buried under ashes in pits 6 inches or more deep. Other growers are content with partially covering the flats with earth on the surface of the ground. Often a covering of straw is used. The large forcers, especially in cramped quarters, put the flats away in racks in a building or cellar where ven-

tilation and temperature especially are under approximate control. In such a situation the stock can be examined from time to time as required, watered, and given such other attention as it needs much more readily than by the other methods.

After thorough rooting and a little top growth has been produced, the flats are taken to the greenhouse. They are put under the benches for a time to lengthen the stems. The space under the benches is curtained with burlap to subdue the light, and high temperature and humidity are maintained. The next place is on the benches, where flowering occurs.

Such is the conventional and approved plan, but many short cuts may be employed. Commonly the period under the bench is omitted entirely; often plantings are made in solid benches, both with good results.

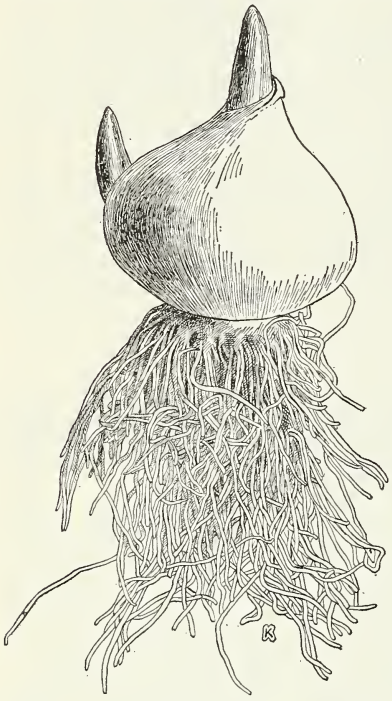


FIGURE 6.—A tulip bulb properly rooted at the time it is taken out of the heeling ground.

The time required for the different steps in forcing will vary with the stocks and with the season when potted. If planting is done the first of September, 12 weeks or more are necessary for thorough rooting. This will bring the flats under the benches in late November. They may go on the benches the middle of December and blossom in January. When planting takes place later, especially after the middle of November, the time required to bring the plants into blossom is shortened, but early flowering cannot be expected from late planting. The bulbs root and develop tops relatively more rapidly the closer to their natural flowering period they are forced.

The traditional directions as to temperature specified 40° F. for rooting, 50° for leaf growth, and 60° for flowering. The figures would be closer to present practices, however, if the temperatures were shoved up about 10° all along the line up to flowering and 5° then. There is nothing definite or fixed about the matter, and fortunately there is considerable flexibility.

The good grower will be governed more by what he sees the plants need than by any rules, but he will avoid forcing the bulbs too hard. High temperatures applied too early, or giving insufficient time for rooting always spell disaster with tulips. Either one results in blindness, green petals, weak stems, and flabby flowers.

While early potting (planting) is necessary for early flowering, it is somewhat of a moot question just how early it is advisable to plant for forcing. There does not seem to be any use in doing it before the first of September. The bulbs do not seem to start rooting

until the temperature begins to drop after the heat of summer. This is as true in field as in flat plantings. Although tulip bulbs are forced by the score of millions each year, some of the points connected with the operations still need to have some data gathered on them.

To summarize the matter of early flowering of tulips, the following is submitted as a common practice: Potting can be done September 1; rooting at 50° to 55° F. up to the last of November; drawing up and growth in subdued light at 60° and high humidity for 10 days or 2 weeks; an inuring to light for a few days, and then full light and a temperature of 60° to 70°. If the condition of the stocks permits, the temperature may be dropped to 60° with profit toward the end of the forcing period.

Of course the Ducs (Duc van Thol) will come in blossom first, then the single earlies. The Darwins are being forced earlier all the time. While considered useful for late February and March years ago, they are now talked of but seldom realized for Christmas. There are good late forcers among the cottage and breeder classes. A rather satisfactory instance of a pot of Darwin tulip Allard Pierson in full flower on December 12 from Oregon-grown bulbs is a matter of record. It shows possibilities for the experimentally inclined.

It is not necessary to draw the plants up in the dark in late forcing, and is seldom of value with the Darwins, as they are tall enough without it. Under living-room conditions, where earliness is not an important consideration and light not very strong, it is perfectly satisfactory to bring the pots from the dark directly into room conditions, but preferably into a location having a temperature of about 60° F.

ASSEMBLING FORCED TULIPS IN PANS FOR SALE

Potted tulips like those in beds to give satisfaction must blossom uniformly. The individual stems should carry their blossoms at the same level, and the flowers should open the same day in order that there be a full display during the life of the exhibit. It is seldom that the 6 to 10 bulbs planted in a pan can be forced to give such a result, and much more difficult is it to grow them in pots so that there is a uniformity of development during the season. Consequently, the bulbs sold in pans or pots are seldom grown in the vessels in which they are sold.

By far the greater number of tulip bulbs are forced in flats and some in solid benches. Those sold in pans are transplanted from where they are grown into the pans preparatory to flowering and sale. This assemblage into pans and pots allows an opportunity to match up the plants so that they will be uniform in height and in time of flowering.

There is quite a knack in this job, for it involves a knowledge of the habit of the tulip plant as well as certain taste in decorative and symmetrical arrangement. The future pleasing effect is dependent not only on the variety itself but quite a great deal on the spacing and arrangement of the plants. This is almost entirely a matter of experience and good taste.

The time at which transplanting should take place is of a great deal of importance. Greenhouse men are agreed that the best time to do it is about the time the blossoms are showing color, for more satisfactory results are secured at this time than earlier. If done too

early, the reestablishment of the plants is not so good and inequalities in growth are likely to occur later.

Very often in the rush of the season this transplanting is poorly done and is the cause of much dissatisfaction to the customer. It is needless to say that care is necessary to pack the soil about the roots, which are injured as little as possible consistent with the expedition necessary. The same precautions apply here as with any other transplanting operations. The soil should be well packed around the bulb and roots, not only to exclude air but to hold the plants up in this case as well, and thorough watering should follow as soon as the task is finished.

ADVANCING THE FLOWERING

The time at which tulip flowers are available naturally is April and May. They are wanted earlier, so resort is had to greenhouse culture, which produces them in late January. There is a demand for them still earlier than this. The flowers that gain a little on the date of general appearance on the market are the ones that command the best price. The constant effort of the grower, therefore, is to gain a little on the time of flowering of his stocks. Various expedients are resorted to to bring tulip flowers in early.

A measure of earliness is gained by early digging. Other conditions being equal, the earlier tulips mature the earlier they are ready to produce the next season's growth. This early digging may not be wholly dependent upon the maturity of the bulbs. It is perfectly practicable to dig them a month or 6 weeks before they mature, as discussed elsewhere (p. 29).

It has been the practice for some years to salvage tulip bulbs from the beds on the grounds of the United States Department of Agriculture at Washington, D. C., as the flowers fade. These bulbs always flower the next year and produce merchantable bulbs at the Bellingham Station.

The bulbs dug thus early invariably flower earlier than Bellingham-grown stock of the same varieties. This is not all. It was soon noticed that the bulbs shipped to Bellingham early and stored to planting time blossom somewhat earlier than those stored in Virginia and shipped to Bellingham just before planting time. The phenomenon, however, seemed to be explained by the work of Blaauw (*2*) in the Netherlands, who demonstrated that bulbs subjected to a moderate temperature of about 70° F. for 3 or 4 weeks after digging and then to about 50° for the remainder of the storage period flowered much earlier than any other. He was able to get Pride of Haarlem in for Christmas.

Early maturity alone gives a measure of earliness, but early maturity coupled with submission to the proper combinations of storage temperatures gives a still earlier flowering. Early maturity and early digging plus manipulation of temperature in storage will produce Darwin tulip flowers for Christmas.

BLINDNESS

A tulip bulb that has reached flowering size and does not flower is said to be blind or to have come blind. Small bulbs also grow without producing flowers, but they are not properly blind. A blind tulip

is one which ought to flower and does not, or one which for some reason has been prevented from performing this function. There is no single cause of blindness, although a single circumstance may be the cause in any particular instance.

Possibly the most common cause of blindness in commercial tulips is heating in the pack. This may be brought about by self-generation of heat, by being placed too close to heating or power plants in the holds of vessels, or by becoming wet. A common cause of blindness is improper handling in forcing. Too great heat early in the season is a potent cause. Bringing the flats into the greenhouse too early, before the buds show, often causes blindness in many plants and green-tipped petals in the others which do open.

So far as the writer's observation goes, bulbs do not go blind from environmental cause in adaptable tulip regions. In other words, bulbs do not develop without flowers in them. A bulb of normal size and outward appearance will have a flower in it at the proper season, and that flower will be produced under normal treatment. If the pots or pans in which tulips are forced are allowed to get thoroughly dry, the flower is likely to be killed, causing blindness.

The writer's experience with transportation in 1918 is very much to the point here. A very full car of tulips, daffodils, and miscellaneous bulbs was shipped from Bellingham by the northern route to Washington, D. C., the first of September. It was 3 weeks in transit and arrived considerably heated in the center of the car. The pack was no different from other years except that sacks of bulbs were put on top of the cases, shutting off aeration. In this case it is evident that the injury done to the bulbs occurred in less than 3 weeks. Probably the actual damage occurred in less than 2 weeks; but in this short time the flower was killed in a large percentage of the tulips in the center of the pack.

The purchaser has an infallible criterion to guide him in the case of injury of this nature. When bulbs are received any time after the middle of August, the outer coats show the effect of heating quite plainly. Any suspicion should be verified by an examination of the flower spike itself. The flower bud at this season should be well developed and easily seen when the bulb is cut open vertically. A dead bud which will come blind is easily recognized by its brown and discolored appearance.

FORCED BULBS

In general, tulip bulbs forced in the greenhouse are not considered as serviceable as those of the daffodil, but they are by no means without value. The trouble is that the stems of tulips are likely to be cut close to the soil. This is certain to be the case in the single earlies. Again, the cutting takes place 10 days or 2 weeks earlier than in the case of the bulbs that are taken up from beds or borders to give room for summer bedding plants. However, by the time the tulips flower the new bulb is close to half grown and it together with some of the larger propagation can be preserved for growing on. Even when taken out of the soil as soon as cut the green bulbs will color up and keep well if properly housed.

Most of the large forcers today root their bulbs on shelves in buildings. The cut flats of tulips can be advantageously returned to

these rooting houses as soon as the flower crop has been harvested and allowed to dry down gradually. Unless the space is needed for some other purpose, the bulbs can remain here until needed for planting or other disposal. If weather permits it is better to place the contents of the flats outside with as little disturbance as possible, to allow better maturity than takes place inside the rooting cellar.

When taken out and cleaned the largest bulbs should flower the next year and be fully as large as if not larger than the best splits produced under normal culture. Of course it is realized that the practicability of such a procedure will depend entirely on the demand for planting stock. If the culture of tulips develops as seems probable, it is not at all unlikely that forced tulips will be saved for planting just as daffodils now are. It is just as practical to do it, and while the resulting product may be comparably smaller, it is much less likely to have picked up troubles in the way of nemas or other parasites in the greenhouse. The greenhouse and bedding bulbs may be made two good sources of planting materials until stocks have become plentiful.

BREEDING

As already pointed out, little is known about the evolution of the modern garden tulip. The line of breeding and even the nature of the original forms from which these tulips were derived are matters of mystery. The Darwins have come to us within the memory of the present generation, but it is not known how the stocks first put on the market by E. H. Krelage were produced.

The grower who starts in to improve tulips in spite of all that has been accomplished must proceed largely in the dark. There is no wealth of information to guide him, and no pedigrees or stud records such as have been recorded by the daffodil breeders of the British Isles.

Within historic times at least, little has been done in the breeding from wild tulips. So far as recorded the improvements made have been within the garden forms extant with comparatively little recourse to the wild species.

It has always been something of an enigma to the writer why the garden tulip should be adapted primarily to regions having low, equable temperatures and high humidity. None of the common garden forms are adapted to warm regions. There are, however, a number of species native to warm countries and even to countries that are arid a portion of the year.

These facts suggest the possibility of a profitable line of breeding, for we are sorely in need of more tulips that can be used, decoratively at least, in warm regions. The use of such forms as *Tulipa clusiana*, *T. sylvestris*, *T. greigi*, *T. turkestanica*, and *T. kaufmanniana* yellow, with the garden forms, might push the use of the tulip into our Southland, where it is now seldom seen and where it is always imperfect. *T. clusiana* especially seems adapted to warm regions. Its use in breeding for better tulips for such regions is suggestive.

The processes of emasculation, pollination, seed saving, and growing of seedlings in the tulip do not differ essentially from the same operations in the breeding of other plants. The pistillate flower is emasculated before the pollen has dehisced, and is protected from insect visitation for a day or two after the stigma has become recep-

tive and the pollen has been applied. The time between emasculation and pollination is rather longer than one would ordinarily expect. Pollination can seldom if ever be done as soon as the flower opens, for the stigma may not become receptive for 2 or 3 days. The exact length of time required varies with the temperature, as in other plants, but at best the stigma of the tulip flower is slow to become viscid indicating its receptivity to pollen.

If the breeder is situated where the atmospheric condition is such that fire blight (*Botrytis*) is not troublesome he is fortunate indeed, for very often in regions having low temperatures and high humidity during the growing season, seed production is interfered with by the inroads of the fire blight organism (p. 56). At the Bellingham Station seed production in the tulip species is frequently rendered nil by the invasion of the tissues of the stem or seed vessels by the *Botrytis* organism. In a situation similar to this a warm position on the south side of a building would be an advantage. Culture of the breeding plants in pots under glass where greater aridity and higher temperature could be created would solve some of the difficulty.

When tulip seed has matured it is best planted without too much delay. At the Bellingham Station it has been planted in late August for spring germination. It comes up readily and vigorously, and in the District of Columbia often volunteers where it has shattered in the garden.

The seed may be planted in the open about 1 inch deep. If put in pots or flats where care is taken to see that moisture is kept at the surface so that the seed does not become dry at any time, one-fourth inch deep may be sufficient. The tulip seed requires about the same conditions for germination as the common garden crops. Seed sown in late August on Puget Sound will come up in the spring. If planted in the spring, germination takes place in 2 or 3 weeks, depending on the temperature, unless the seed is held too warm and dry over winter, a condition that will retard germination.

In spite of the oft-repeated injunction to dig tulip bulbs every year, the writer rather favors the protection of the tulip seed bed from inroads of mice and other enemies so that the seedlings may be left undug the first season. This saves much trouble in digging and finding as well as preserving the delicate young seedling bulbs.

After the seedlings have ripened it is a good plan to cover the beds with an additional one-half to 1 inch of soil. They will come up through this extra covering the next spring and will be all the better for the extra protection.

There is one thing about the growing of the seedling hybrids for future selection in the tulip that may be somewhat confusing to the breeder. The seedlings are very likely to produce droppers. If the whole structure drops, all is well and good; but if, as is common, only a part of the substance of the young bulb drops, there will be in the progeny some duplications.

The time it takes to bring tulip seedlings to the flowering stage will vary with the conditions of culture more than anything else. Usually a progeny will begin to flower the fourth year, and flower fully the fifth. It may be necessary to hold the stock produced for the sixth year's inflorescence before a reliable estimate is possible.

PRODUCTION OF CHOICE STOCKS

In no group of plants is there a better opportunity for the production of superstocks than in the tulip. The bulbs show their quality so plainly that the veriest tyro will recognize it, which means that the visible qualities will substantiate the advance in price asked. There is here, therefore, the finest kind of an opportunity for the capable grower to produce choice materials for a discriminating clientele, which always exists, and is willing to pay extra for extra quality as soon as it is demonstrated that such a quality will be furnished.

Usually the choicest of stocks are not produced in 1 year but require good culture for a second year. Of course it is possible to select from any moderately well-grown stock top quality in a small amount of material, but to bring the general stock to top quality is another and a very different matter.

At the Bellingham Station the best tulip bulbs are always produced on rotted timothy and clover turf 3 or more years of age. It is this preparation that puts the soil in the best physical condition. The addition of 1,200 pounds of a high-grade commercial fertilizer makes a preparation that has produced maximum crops. The basis for this should be a friable clay loam, which is preferable to a light sandy soil.

The planting stock for extra quality production should be of the best of the round bulbs, if, indeed, the best of the commercial grades would not be preferable. Such bulbs should be set with ample spacing, more than is usually given in commercial production, say 8 by 14 inches. The depth of setting should be medium, fully 4 inches. It is well known that deep planting in most bulbs diminishes the size somewhat, while shallow setting causes more splitting.

Prime quality again will demand that these finely produced stocks be dug as soon as they are ripe. Dependence for a nicety of performance cannot be placed here on the tops in all cases. The safest way is to dig down and examine the bulbs, for they should be dug when one-half to two-thirds of the coat has turned brown.

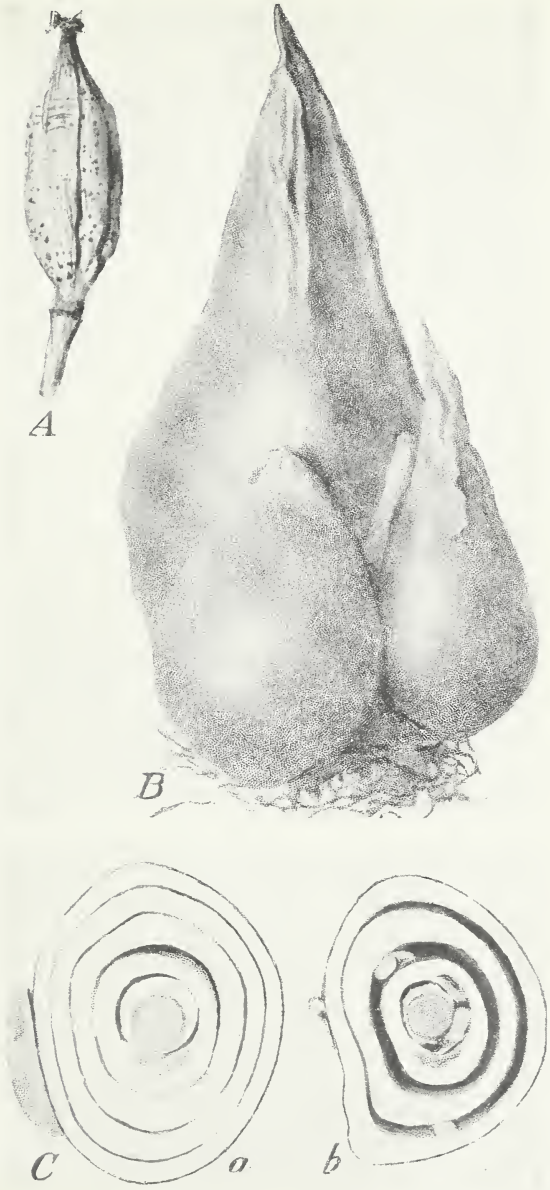
DISEASES, PESTS, AND ABNORMALITIES

The organisms that live on the tulip and do it injury have been remarkably few in the cultures on Puget Sound, which form the basis of this discussion. The more limited cultures in Virginia have shown even less trouble with parasites. The difference seems to be due to climatic conditions primarily, and possibly to a lesser extent to character of soil. The climatic conditions on Puget Sound, however, are such as to produce plenty of trouble with one parasite, at least if certain methods of procedure are not rigidly adhered to.

FIRE BLIGHT (BOTRYTIS)

Fire blight, or "fire" (pl. 12, *A*), is by far the most serious trouble with which the tulip grower in the Pacific Northwest has to contend. The trouble is much less serious in the situation in which cultures have been carried on in Virginia.

The injury manifests itself by dead spots or patches on the leaves and stems, even involving the entire inflorescence and in bad attacks



A, Dwarfed seed pod of cottage tulip Retroflexa, showing the resting stage (sclerotia) of the fire blight fungus (*Botrytis*); *B*, clump of Darwin tulips as dug, showing improperly filled coats, due to bad cultural conditions; *C*, cross sections of (*a*) normal bulb at the time it should be brought out of the heeling ground, and (*b*) excessively dried bulb at the same time. Note the latter has not taken up moisture in the soil to swell up the bulb layers.

the entire plant, which may die prematurely. Occasionally the spotting occurs in the flower only, when no particular injury occurs to the bulb production.

The attack of the fire blight is predicated upon certain conditions. In the climate of the Pacific Northwest it is more than likely to be destructive whenever tulips follow tulips on the same soil, or when the plants are bruised by hail or cultivation during low temperatures and excessive atmospheric humidity, or when frosty nights prevail under similar conditions of humidity and day temperatures run high with full sunshine.

Just what proportion of the injury in any attack of fire blight should be charged to the detrimental natural environmental agencies and what to the mold *Botrytis* is difficult to say, and from a practical point of view this may not be of first importance. In any case of injury from the natural agencies mentioned, the tissues turn brown and die. Very often it is not possible to find the mold. However, it can commonly be found on the more poorly aerated dead portions of the plant. Any death of leaves in whole or in part, or browning of the inflorescence, or spotting of foliage or petals is commonly referred to as fire blight whether the mold is observable or not.

Naturally one of the first questions confronting the practical grower when he has a case of fire injury concerns the effect on the next crop. Does an attack of the blight one season prejudice the stock to the same trouble next year? While there is no intention to be positive or to dogmatize on the matter, it is not believed that it necessarily does.

A number of years ago a call to examine and advise regarding some "fired" tulips in the Willamette Valley proved to be very enlightening on this point. On one side of the highway was a planting of tulips obtained the previous autumn from the old C. W. Ward plantings at McKinleyville, Calif., which were known to have been badly fired. They had been left undug the year before. Bulbs dug for examination in this planting showed plenty of the small black specks (sclerotia), in which the mold lives over winter, on the inside of the old coats still on the bulbs. Yet in spite of this there was no fire in these stocks and there was no spotting of the flowers. On the other side of the highway was another planting of Darwins like the others, from the previous year's culture from imported bulbs grown in the same soil. The crop was normal and clean the first year after importation, but this year there were no merchantable flowers, owing to fire blight.

An observant grower who examines the old herbage of the tulip late in the season cannot but be impressed with the prevalence of the mold *Botrytis*. It is doubtful whether any appreciable amount of it can be found in the Pacific Northwest without the presence of the mold or sclerotia. Yet it is only in very bad attacks that they are found under the old coats, and in the case noted above at least they did not produce fire the next year on fresh ground.

Let it be understood that there is no disposition to maintain that tulip stocks that have fired are as good as those that have not, for that is the exact reverse of the facts. They are at least smaller and therefore comparably weaker as planting materials than unfired materials. As to whether the individual bulbs are as strong as com-

parable sizes in unfired stocks, the writer must plead ignorance. It would require some very carefully conducted experiments to determine this. The point which it is desired to emphasize is that the presence of fire one year does not necessarily prejudice the use of the stock for planting the next. This is indeed fortunate, for more or less fire is to be found practically every year in thick commercial plantings.

The reaction to fire blight differs in different varieties. The varieties most subject at the Bellingham Station have been Allard Pierson, Valentin, Sieraad van Flora, and Psyche. The reason for this appears to be due in large measure to the earliness of these varieties. They are among the earliest of the Darwins and consequently are subjected to greater vicissitudes of climate than the later varieties. On the other hand, the single earlies come still earlier, but they are not so subject to the trouble.

One occasionally hears the advice to cut off the portions of the leaves that have died, to prevent the spread of the blight. This may at times be efficacious, but in all cases observed the injury has been so general that this remedy or even a fungicide spray is of little avail. If the plants are covered with the fungicide residue when the conditions that cause the attack obtain, a check may occur, but when the attack has taken place it is usually too late to apply the remedy efficaciously.

Another difficulty in applying remedial measures to fired tulips results from the density of the planting. It is difficult to get through a planting such as described here with spray or other machinery. To provide for such a treatment the density of the station's planting would have to be reduced by 2 or 3.

The best way to guard against the fire blight in tulips is to employ two precautionary measures. The first consists of the practice of a rotation in which tulips are not grown in the same soil more often than once in 3 years. The second consists of the practice of clean culture wherein the surface of the soil is free of debris, strawy litter, or weeds which prevent aeration.

A crop of lilies should be looked upon as being just as detrimental as the tulip itself if too close in the rotation. The use of a straw mulch is taboo with a crop of tulips, for the reason that decaying strawy litter tends to aggravate an attack of fire because the organism thrives on such a substratum. In a region like Virginia, across the Potomac from the city of Washington, these restrictions are not so rigidly required as they are on Puget Sound, because there is more heat, less dew, the plants dry off quicker in the morning, and the atmosphere is generally less humid.

In beds and borders the requirements of rotation are not so exacting, because the plants are gouged out as soon as they have finished blossoming, and little of the crop residue is left in the soil. Trouble due to accumulation of plant remains is slower to assert itself under these conditions, but repeated crops of this kind bring trouble from fire blight sooner or later, and quicker in a low-temperatured, humid locality.

Although it is risky to plant tulips after tulips or to leave tulips undug over a season in commercial culture on Puget Sound, any of the Darwin, single early, or cottage varieties when naturalized in

scattering clumps in a meadow get along year after year without blighting. At the Bellingham Station a certain plot in which there were 80 or more varieties of tulips scattered as missed in the digging thrived without blighting to any extent for 8 years in the timothy and clover meadow.

As with many other horticultural crops, care should be exercised in the handling of the refuse. It need not be burned or otherwise wasted, but it should be handled so as to avoid its use on land that is to grow tulips or other bulbs, as an added precaution against the spread and accumulation of the spores of fungi that cause diseases. This is a very important matter and should not be overlooked.

This debris, made up largely of stems and leaves hoed off the beds at digging time, flowers cut off before the petals drop, old bulb coats, and imperfect, rotted, and undersized bulbets cleaned out of the stock during the time it is in the bulb house, should be composted and thoroughly rotted before being used on any ground; otherwise the bulbs will come up as weeds in other crops and be a source of annoyance and loss indefinitely. There are few weeds more persistent in cultivated fields than tulips that have been left undug or plowed in with unrotted compost.

Old tops should by no means be scattered about where they are likely to get into ground that is to be planted to tulips, lilies, or any liliaceous plants in the next 2 years. It would be as detrimental to grow tulips after tulips as this. No injury has been seen from tops plowed under on the plots where tulips are dug when such plots are put down to grass for 2 or 3 years. This is really the best disposition to make of them and of other tulip crop residues.

MOSAIC (BREAKING, ETC.)

The "mysterious" change occurring so frequently in tulips, causing an irregular distribution of the coloring matter of both flower and foliage, is referred to by various appellations. The old terms rectification and breaking were applied at a time before the disease nature of the phenomenon was realized. It is not until recently that the disease nature of the broken tulips has been appreciated and accepted, although one astute observer hinted that the rectified tulip is a sick one as early as 1807 (*7*). The historical side of the subject has been treated recently by McKay and Warner (*6*).

The broken or rectified tulip has been known from very ancient times. Even before the plants were introduced into western Europe the Turks had them and appreciated them. They have been popular from that day to the last few years; indeed, the rectified tulip has been looked upon as the acme of perfection and the condition to which all self-colored seedlings were destined.

Two or three circumstances have contributed to the continued popularity of these striped and feathered forms of blossoms. Not the least has been the investigational interest in the British Isles into the cause and the method of breaking. Here complicated studies extending over a third of a century or more with continuous performance records of pedigreed bulbs have been preserved until recently. Complicated formulae for handling based on a continuous record of self-colored individual bulbs were developed for the pur-

pose of determining the time, the method, and the cause or causes of the breaking or rectification.

Another cause of the deep interest has been the inherent beauty of some of the broken individuals. Fashions in tulips as in all things change. For generations the interest was in the more minute beauty of a multicolored, delicately marked individual plant. Today the interest is more in a solid color and a mass effect; consequently the broken tulips are now less popular.

Another factor contributing to the popularity of the broken tulip has been the keen perception of the commercial producers and dealers to capitalize on the popular interest by putting on the market broken forms of several of the commercial groups. These novelties, usually short lived but frequently supplanted by others in the same class, have kept up a succession of broken tulips of profitable demand.

Although the virus disease nature of the broken tulip is generally accepted, there are still some links in the chain of evidence unforged. It is known that the presence of broken tulips in a planting contributes to a spread of the trouble, that breaking is more pronounced in warm regions, and that three species of aphids are now recorded as being carriers of the disease.

The broken tulip is too well known to need any extended characterization. It is in the modified distribution of the coloring matter of the flower that the interest lies, although there is a mosaic effect produced in the distribution of the chlorophyll of the entire plant. This is easily detected when looked for, but is usually rather faint. No two individuals break exactly alike, and only an occasional one breaks attractively. Again, some varieties give more attractive breaks than others.

There are two types of results produced by the breaking, based on the natural coloration of the flowers. In one case the effect is produced by a disturbance in the distribution of the pigment in the superficial (epidermal) layers of the petals alone. In the other case it is an effect produced by a similarly disturbed distribution in the epidermal tissues superimposed upon a yellow ground (mesophyll between the epidermal layers).

The statement is sometimes made that white and yellow tulips cannot "break" or "rectify." This is true in a florist's sense only. The plants themselves become truly affected with mosaic the same as other colors, and inconspicuous patterns may be detected in the flowers, but the flowers do not become spectacularly marked.

All of this is very interesting and of some importance, but the main thing for the grower is to know what to do about it. There is no effective treatment known for a virus disease. All that can be recommended is to destroy ruthlessly all affected individuals. This, of course, means shunning the classes of broken tulips in their entirety; otherwise the grower runs a risk to the self-colored stocks. How great this risk is considered to be is still largely a matter of personal opinion. The writer, while recognizing the necessity of care in the securing of foundation stock to be free from broken forms and the necessity of carefully roguing out occasional strays that may appear, has had so little trouble in 15 years of intensive tulip experience as to put the soft pedal on any attempt to create alarm over the matter.

At the Bellingham Station where there have been imported not less than 700 lots of tulips and where broken forms were grown for years, no appreciable spread of the trouble has occurred. It is true that aphids have not been present to any extent in the tulip plantings. While it is conceded that the breaking is more prevalent in warm regions, there has been no more difficulty experienced on Arlington Farm than on Puget Sound. However, no broken tulips have been grown in the Virginia situation, and seldom has a broken stray been encountered.

Experience at the Bellingham Station and the experience of thousands of importations annually do not portend any appreciable trouble in the securing of stocks free from mosaic for foundation plantings. On the other hand, the roguing out of an occasional stray is an efficacious remedy. The one caution that it seems well to make is to avoid tulips grown in a warm region under conditions of neglect. An examination during the flowering season even here would insure protection.

BULB INJURIES AND DEFECTS

SOFT BULBS

Bulbs affected with storage rot, known as soft bulbs, have been observed as early as cleaning time, 2 to 4 weeks after digging, and frequently the rotting continues in the pack on the way to market. To one accustomed to handling tulips, the incipient stage of this decay when it has reached no farther than the outer scale is readily detected by its clammy, dead touch. It is an interesting thing that the better the tulips are grown the more likely they are to have soft bulbs among the stock. Poor, small, starved stocks are not so subject to this storage rot.

This trouble seems to be caused entirely by rough handling, the large bulb varieties always suffering worse than the smaller ones. While the tulip bulb is effectively protected from certain injuries by its continuous brown coat, the coat furnishes very little protection against bruising caused by a drop of 12 inches. Even dropping the bulbs into a box or basket, or pouring them from one vessel to another, requiring a drop of but a foot, is sufficient to bruise these large bulbs. They are heavy, solid, and delicate of tissue.

UNFILLED COATS

It frequently happens that tulip bulbs as dug do not have the normally smooth, tight-fitting coats, but the mature bulb of the clump presents a wrinkled appearance in whole or in part (pl. 12, *B*). The base may present a normal appearance while the upper fourth is empty. The condition has been considered at times to be a disease, but it should be looked upon as a reaction to unfavorable conditions for growth. It is very likely to occur when good quality bulbs are planted under poor fertility, droughty conditions during growth, or on light lean sands which are both dry and poor.

SHRIVELING

The reaction of the tulip to excessive desiccation in storage (pl. 12, *C*, *b*) has sometimes been looked on by growers as a diseased condition. Often such evil influences may not be reflected in the

outward appearances except in loss of weight. Toward the end of the storage season there will usually be found more or less empty space between the bulb layers. This cannot be avoided, but excessive drying devitalizes the bulbs. It is a noticeable thing that bulbs dried out excessively do not plump up again when planted in moist earth, like, for instance, the roots of ranunculus.

ANIMAL AND INSECT PESTS

RODENTS

Mice, moles, and gophers are very destructive to tulips. Moles and gophers can be trapped; mice are best combated with poison bait. At the Bellingham Station poison for mice is planted as regularly and carefully as the tulips. This whole subject is treated in Farmers' Bulletin 1247 (*11*).

APHIDS

In some sections aphids may cause a great deal of injury by disfiguring the tulip. Attack of the insects is particularly annoying in the greenhouse. On Puget Sound under field conditions thus far they have not been a serious factor. The insects are not difficult to control through the use of nicotine preparations applied as dusts or sprays as directed on the commercial preparations of these chemicals. The subject of aphids is discussed in Farmers' Bulletin 1362 (*12*).

LESSER BULB FLIES

The larva of the lesser bulb fly (*Eumerus* spp.) is common in tulip bulbs that have rotted from any cause. Often they are quite numerous, a dozen or more in a rotted bulb, when they are likely to create concern. They do not normally attack sound bulbs, however, but gain entrance often when rotting occurs from some other cause.

ABERRANT FORMS ("THIEVES")

The aberrant forms known as tulip "thieves" have mainly a historical interest, for in no instance out of the 700 or more importations made in the past 20 years have they been found. However, one of the varieties of thieves appeared suddenly in the stocks of single early tulips at the Bellingham Station in 1919–20, 10 years after their importation. The circumstances indicate that without doubt they were imported and placed in the stocks, suggesting that although modern tulip stocks are not contaminated with thieves, it is possible that growers may encounter them as the Bellingham Station has.

Many varieties of thieves have been listed. They resemble the *Tulipa didieri* group more closely than any other, are shy bloomers, inordinately rapid propagators, possessing undersized bulbs which sieve back into the planting materials, thus complicating matters and rendering the varieties thus contaminated almost worthless. The station's stocks were cleaned by planting only large-size bulbs and then roguing out all thieves and bulbs that did not flower.

The time was in Europe when the thieves were claimed to have a spontaneous origin. The common garden tulips were said to turn

into these worthless forms in some mysterious manner. There is no question, however, that they are as stable as any other varieties and get into stocks by being placed there.

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